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Slaughter of animals: poultry

EFSA Panel on Animal Health and Welfare (AHAW)

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Slaughter of animals: poultry

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Abstract

The killing of poultry for human consumption (slaughtering) can take place in a slaughterhouse or during on-farm slaughter. The processes of slaughtering that were assessed, from the arrival of birds in containers until their death, were grouped into three main phases: pre-stunning (including arrival, unloading of containers from the truck, lairage, handling/removing of birds from containers); stunning (including restraint); and bleeding (including bleeding following stunning and bleeding during slaughter without stunning). Stunning methods were grouped into three categories: electrical, controlled modified atmosphere and mechanical. In total, 35 hazards were identified and characterised, most of them related to stunning and bleeding. Staff were identified as the origin of 29 hazards, and 28 hazards were attributed to the lack of appropriate skill sets needed to perform tasks or to fatigue. Corrective and preventive measures were assessed: measures to correct hazards were identified for 11 hazards, with management shown to have a crucial role in prevention. Ten welfare consequences, the birds can be exposed to during slaughter, were identified: consciousness, heat stress, cold stress, prolonged thirst, prolonged hunger, restriction of movements, pain, fear, distress and respiratory distress. Welfare consequences and relevant animal-based measures were described. Outcome tables linking hazards, welfare consequences, animal-based measures, origins, and preventive and corrective measures were developed for each process. Mitigation measures to minimise welfare consequences were also proposed.

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Keywords: poultry, slaughter, hazards, animal welfare consequences, ABMs, preventive/corrective measures

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Summary

In 2009, the European Union (EU) adopted Council Regulation (EC) No 1099/2009 'on the protection of animals at the time of killing', which was prepared on the basis of two scientific opinions adopted by the European Food Safety Authority (EFSA) in 2004 and 2006. Successively (in 2012, 2013, 2014, 2015 and 2017), EFSA produced other scientific opinions related to this subject.

In parallel, since 2005, the World Organisation for Animal Health (OIE) has developed two chapters in its Terrestrial Animal Health Code: (i) Slaughter of animals (Chapter 7.5) and (ii) Killing of animals for disease control purposes (Chapter 7.6). OIE has created an ad hoc working group to revise these two chapters.

Against this background, the European Commission requested EFSA to write a scientific opinion providing an independent view on the slaughter of domestic birds.

With specific reference to arrival of the animals, unloading, lairage, restraint, stunning, bleeding, emergency killing and methods, procedures or practices unacceptable on welfare grounds, EFSA was asked to: identify the animal welfare hazards and their possible origins in terms of facilities/equipment and staff (Term of Reference (ToR)-1); define qualitative or measurable criteria to assess performance on animal welfare (animal-based measures (ABMs)) (ToR-2); provide preventive and corrective measures (structural or managerial) to address the hazards identified (ToR-3); and point out specific hazards related to species or type of animal (e.g. young ones, etc.) (ToR-4). In addition, the European Commission asked EFSA to provide measures to mitigate the welfare consequences that can be caused by the identified hazards.

This scientific opinion aims at updating the above reported EFSA outputs by reviewing the most recent scientific publications and providing the European Commission with a sound scientific basis for future discussions at international level on the welfare of birds in the context of slaughter.

The animal species that are considered in this assessment are the ones that pertain to the category 'poultry' as defined by the OIE, that can be put in crates and containers, such as chickens, turkeys, quail, ducks and geese, and game birds. It does not concern ratites, which are free-moving animals.

The mandate also requested a list of unacceptable methods, procedures or practices that need to be analysed in terms of the above welfare aspects. It has to be noted that methods, procedures or practices cannot be subjected to a risk assessment procedure if there is no published scientific evidence related to them. In the light of this, Chapter 7.5.10 of the OIE Terrestrial Animal Health Code lists several practices it considers unacceptable, and the Panel has no scientific arguments to disagree with this list.

Council Regulation (EC) No 1099/2009 defines slaughtering as 'the killing of animals intended for human consumption' and the related operations are 'operations that take place in the context and at the location where the animals are slaughtered'. This opinion concerns the killing of poultry for human consumption that could take place in a slaughter plant or during on-farm slaughter. In the context of this opinion, each related operation is a process, and several related operations (processes) are grouped in phases. The phases that have been assessed in this opinion, from arrival until the animal is dead (including slaughtering without stunning), are: Phase 1 – pre-stunning, Phase 2 – stunning and Phase 3 – bleeding. Phase 1 includes the following processes (in chronological order): (a) transportation (excluded from this scientific opinion), (b) arrival, (c) unloading of containers from the truck, (d) lairage-, and (e) handling and removing of birds from containers. Considering that the restraint of poultry prior to stunning varies depending on the stunning method, restraint has been assessed as a part of the relevant stunning method (Phase 2). The bleeding phase (Phase 3) includes: (a) the bleeding of poultry following stunning and (b) the bleeding during slaughter without stunning, including the restraint.

To address the mandate, three main approaches were used in developing this opinion: (i) literature search and (ii) consultation of Member States (MSs) representatives, followed by (iii) expert opinion through working group (WG) discussion. The literature search was carried out to identify peer-reviewed scientific evidence providing information on the elements requested by the ToRs (i.e. description of the processes, identification of welfare hazards and their origin, preventive and corrective measures, welfare consequences and related ABMs) on the topic of slaughter of poultry (killing of poultry for human consumption). During the 2018 meeting of the representatives of the EU MSs' organisations designated as National Contact Points (NCPs) for Council Regulation (EC) No 1099/2009 (NCPs Network meeting), hazards pertaining to each process of slaughtering were identified and discussed to gather information on which are most common in the EU and are considered by national authorities as the most urgent to be addressed in order to safeguard animal welfare during the slaughtering of poultry.

From the available literature, their own knowledge and the results of the discussion with the NCPs Network, the WG experts identified the processes that should be included in the assessment and produced a list containing the possible welfare hazards of each process related to the slaughter of poultry. To address the ToRs, experts identified the origin of each hazard (ToR-1) and related preventive and corrective measures (ToR-3), along with the possible welfare consequences of the hazards and relevant ABMs (ToR-2). Measures to mitigate the welfare consequences were also considered. Specific hazards were identified in the case of certain categories of birds (e.g. heavy animals, laying hens) (ToR-4). In addition, uncertainty analysis on the hazard identification was carried out, but limited to quantification of the probability of identifying false-positive or false-negative hazards.

As this opinion will be used by the European Commission to address the OIE standards, more methods for slaughter than those reported in Council Regulation (EC) No 1099/2009 have been considered. However, among the methods that are used worldwide, the following criteria have been applied to the selection of methods to include in this assessment: (a) all methods with described technical specifications known to the experts, not only those described in Council Regulation (EC) No 1099/2009, (b) methods currently used for slaughter of birds as well as those still in development but likely to become commercially applicable, and (c) methods for which the welfare aspects (in terms of welfare hazards, welfare consequences, ABMs, preventive and corrective measures) are described sufficiently in the scientific literature. Applying these criteria, some methods that may be applied worldwide have not been included in the current assessment.

The stunning methods that have been identified as relevant for poultry can be grouped in three categories: (1) electrical, (2) controlled atmospheres and (3) mechanical.

Electrical methods include waterbath, head-only and head-to-body; however, in practice for slaughtering birds, only the first two are reported in the scientific literature and will be described in this opinion. Controlled atmosphere stunning (CAS) methods include gas stunning and low atmospheric pressure stunning (LAPS); they are used to avoid the pain associated with shackling conscious birds occurring in electrical or mechanical stunning methods. The use of CAS is limited to birds in containers or on conveyors. The mechanical methods that have been described in this report are captive bolt, percussive blow to the head, cervical dislocation and decapitation. The latter should only be applied to kill unconscious birds, and the other mechanical methods are mainly used as the backup method or for small-scale slaughtering as in small abattoirs or on-farm slaughter.

In this opinion, for each process related to slaughter, a description on how it is technically and practically carried out and how the birds are kept (e.g. if still in containers or in a restraint device) is provided. In addition, a list of the main hazards that have been identified to occur during the process and the relevant welfare consequences is reported; in some specific cases, ABMs are also provided as examples. A third section with a brief description of the key points for assessing welfare of poultry has been also included.

In answering ToR-1, 35 welfare related hazards were identified, from arrival of the birds at the slaughter plant until they were dead. Some of these hazards were common to different phases. All the processes described in this opinion have hazards; regarding the stunning methods, some present hazards related to the induction phase to unconsciousness (CAS), others to the restraint of birds (i.e. electrical and mechanical methods).

Some hazards are inherent to the stunning method and cannot be avoided (e.g. shackling in waterbath), other hazards originate from suboptimal application of the method, mainly due to unskilled staff (e.g. rough handling, use of wrong parameters e.g. for electrical methods). In fact, most of the hazards (29) had staff as origin, and 28 hazards could be attributed to lack of appropriate skill sets needed to perform tasks or to fatigue.

The uncertainty analysis on the set of hazards for each process, provided in this opinion, revealed that the experts were 90–95% certain they identified the main and most common welfare hazards considered in this assessment according to the three criteria described in the Interpretation of ToRs. However, when considering a global perspective (owing to the lack of documented evidence on all possible variations in the processes and methods being practiced on a worldwide scale), the experts were 95–99% certain that at least one welfare hazard is missing. Regarding the possible inclusion of false-positive hazards, the experts were 95–99% certain that all listed hazards exist during the slaughter of poultry. This certainty applies to all processes described in this opinion except the hazard 'expansion of gases in the body cavity' during stunning with LAPS, where the lack of field experience and scientific data reduces the level of certainty to 33–66%.

The mandate also asked for definitions of qualitative or measurable (quantitative) criteria to assess performance (i.e. consequences) on animal welfare (ABMs; ToR-2); this ToR was addressed by

identifying the negative consequences on the welfare (so called 'welfare consequences') occurring to birds due to the identified hazards and the relevant ABMs that can be used to assess qualitatively or quantitatively these welfare consequences. Ten welfare consequences have been identified: consciousness, heat stress, cold stress, prolonged thirst, prolonged hunger, restriction of movements, pain, fear, distress and respiratory distress. Birds experience these welfare consequences only when they are conscious; all animals will therefore experience the welfare consequences of the hazards occurring in the pre-stunning phase, in restraint (when applied to conscious animals) and in slaughter without stunning. Only a proportion of animals will be subjected to the welfare consequences of hazards they are exposed to after stunning: these are the animals for which stunning was ineffective or which recovered consciousness before death.

Animal welfare consequences can be the result of one or more hazards. Exposure to multiple hazards would have a cumulative effect on the welfare consequences (e.g. pain due to injury caused by rough handling during catching will lead to more severe pain during shackling).

List and definitions of ABMs to be used for assessing the welfare consequences have been provided in this Opinion. However, under certain circumstances, not all the ABMs can be used because of low feasibility (e.g. at arrival/during lairage due to the lack of accessibility to the animals in containers). Even if welfare consequences cannot be assessed during the slaughter of poultry, it does not imply they do not exist; in fact, if the hazard is present, it should be assumed that the related welfare consequences are also experienced by the birds.

In response to ToR-3, preventive and corrective measures for the identified hazards have been identified and described. Some are specific for a hazard; others can apply to multiple hazards (e.g. staff training and rotation). For most of the hazards (30), preventive measures can be put in place with management having a crucial role in prevention. Corrective measures were identified for 11 hazards; when they are not available or feasible to put in place, actions to mitigate the welfare consequences caused by the identified hazards should be put in place.

Finally, outcome tables linking all the mentioned elements requested by the ToRs (identification of welfare hazards, origin, preventive and corrective measures, welfare consequences and related ABMs) have been produced for each process in the slaughter of poultry to provide an overall outcome, where all retrieved information is presented concisely. Conclusions and recommendations of this scientific opinion are mainly based on the outcome tables. Specific recommendations are provided for specific processes of slaughter. To spare birds from severe welfare consequences such as pain and fear: (a) animals should not be shackled while conscious, (b) animals should not be bled while conscious and (c) death must be monitored and confirmed in birds before entering the scalding tank.

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1. Introduction

1.1. Background and Terms of Reference (ToR) as provided by the requestor

1.1.1. Background

The Union adopted in 2009 Council Regulation (EC) No 1099/2009¹ *on the protection of animals at the time of killing*. This piece of legislation was prepared based on two EFSA opinions, respectively, adopted in 2004² and 2006.³ The EFSA provided additional opinions related to this subject in 2012,⁴ 2013^{5,6,7,8,9,10} 2014^{11,12} 2015¹³ and 2017.^{14,15}

In parallel, since 2005, the World Organisation for Animal Health (OIE) has developed in its Terrestrial Animal Health Code two chapters covering a similar scope:

- Slaughter of animals (Chapter 7.5);
- Killing of animals for disease control purposes (Chapter 7.6)

The chapter slaughter of animals covers the following species: cattle, buffalo, bison, sheep, goats, camelids, deer, horses, pigs, ratites, rabbits and poultry (domestic birds as defined by the OIE).

The OIE has created an ad hoc working group with the view to revise the two chapters.

Against this background, the Commission would like to request the EFSA to review the scientific publications provided and possibly other sources to provide a sound scientific basis for the future discussions at international level on the welfare of animals in the context of slaughter (i.e. killing animals for human consumption) or other types of killing (killing for other purposes than slaughter).

1.1.2. Terms of Reference

The Commission therefore considers it opportune to request EFSA to give an independent view on the slaughter of animals (killing for human consumption) concerning two categories of animals:

- free moving animals (cattle, buffalo, bison, sheep, goats, camelids, deer, horses, pigs, ratites)
- animals in crates or containers (i.e. rabbits and domestic birds).

The request covers the following processes and issues:

- arrival of the animals,
- unloading,
- lairage,
- handling and moving of the animals (free moving animals only)
- restraint,
- stunning
- bleeding
- slaughter of pregnant animals (free moving animals only)
- emergency killing (reasons and conditions under which animals have to be killed outside the normal slaughter line),

¹ OJ L 303, 18.11.2009, p. 1.

² The welfare aspects of the main systems of stunning and killing the main commercial species of animals. EFSA Journal 2004; 45, 1–29.

³ The welfare aspects of the main systems of stunning and killing applied to commercially farmed deer, goats, rabbits, ostriches, ducks, geese and quail. EFSA Journal 2006; 326, 1–18.

⁴ Electrical requirements for waterbath equipment applicable for poultry. EFSA Journal 2012;10(6):2757.

⁵ Electrical parameters for the stunning of lambs and kid goats. EFSA Journal 2013;11(6):3249.

⁶ Monitoring procedures at slaughterhouses for bovines. EFSA Journal 2013;11(12):3460.

⁷ Monitoring procedures at slaughterhouses for pigs. EFSA Journal 2013;11(12):3523.

⁸ Monitoring procedures at slaughterhouses for poultry. EFSA Journal 2013;11(12):3521.

⁹ Monitoring procedures at slaughterhouses for sheep and goats. EFSA Journal 2013;11(12):3522.

¹⁰ The use of carbon dioxide for stunning rabbits. EFSA Journal 2013;11(6):3250.

¹¹ The use of low atmosphere pressure system (LAPS) for stunning poultry. EFSA Journal 2014;12(1):3488.

¹² Electrical requirements for poultry waterbath stunning equipment. EFSA Journal 2014;12(7):3745.

¹³ The scientific assessment of studies on electrical parameters for stunning of small ruminants (ovine and caprine species). EFSA Journal 2015;13(2):4023.

¹⁴ The low atmospheric pressure system for stunning broiler chickens. EFSA Journal 2017;15(12):5056.

¹⁵ The animal welfare aspects in respect of the slaughter or killing of pregnant livestock animals (cattle, pigs, sheep, goats, horses). EFSA Journal 2017;15(5):4782.

- unacceptable methods, procedures or practices on welfare grounds.

For each process or issue in each category (i.e. free moving/in crates or containers), EFSA will:

- ToR-1: Identify the animal welfare hazards and their possible origins (facilities/equipment, staff),
- ToR-2: Define qualitative or measurable criteria to assess performance on animal welfare (animal-based measures (ABM)),
- ToR-3: Provide preventive and corrective measures to address the hazards identified (through structural or managerial measures),
- ToR-4: Point out specific hazards related to species or types of animals (young, with horns, etc.).

1.2. Interpretation of the Terms of Reference

This Scientific opinion concerns the slaughter of poultry (as defined by the World Organisation for Animal Health (OIE, 2018))¹⁶ that can be put in crates and containers, such as chickens, turkeys, quails, ducks and geese, and game birds, but will not concern ratites, which are free moving animals that will be treated in another Scientific Opinion.

The European Commission asked EFSA to provide an independent view on the slaughtering of poultry, covering all processes; for each of these, several welfare aspects needed to be analysed (including, e.g. welfare hazards, welfare consequences and preventive/corrective measures).

This opinion will use definitions relating to the killing of poultry, including the related operations, provided by Council Regulation (EC) No 1099/2009 of 24 September 2009¹⁷ on the protection of animals at the time of killing, which entered into force in January 2013. The Regulation defines slaughtering as the killing of animals intended for human consumption; the related operations include handling, lairaging, restraining, stunning and bleeding of animals that take place in the context and at the location where the animals are slaughtered.

This opinion will therefore concern the killing of poultry for human consumption that could take place in a slaughter plant or during on-farm slaughter, from arrival until the animal is dead (including slaughter without stunning). In the context of this opinion, each related operation is a process, and several related operations (processes) are grouped into phases. The phases that will be assessed in this opinion, from arrival until the animal is dead (including slaughtering without stunning), are: Phase 1 – pre-stunning, Phase 2 – stunning and Phase 3 – bleeding. Phase 1 includes (in chronological order): (a) transportation (excluded from this scientific opinion), (b) arrival, (c) unloading of containers from the truck, (d) lairage and (e) handling and removing of birds from containers. Because restraint of poultry prior to stunning varies depending on the stunning method, restraint will be assessed as a part of the relevant stunning method (Phase 2). The bleeding phase (Phase 3) includes: (a) the bleeding of poultry following stunning and (b) the bleeding during slaughter without stunning, including the restraint.

Because of the diversity of available stunning methods, this opinion will consider the assessment of hazards, welfare consequences, related ABMs and mitigation measures, origin of hazards and preventive/corrective actions for each method.

The mandate requests EFSA to identify hazards at different stages (processes) of slaughtering and their relevant origins in terms of equipment/facilities or staff (ToR-1). Some hazards may originate from the farm or during transport; however, on-farm animal rearing, catching and transport are excluded from this assessment.

This opinion will report the hazards that can occur during slaughtering of birds in all slaughterhouses (from industrial plants with automated processes to on-farm manual slaughter), but not all of them apply to all slaughter situations, i.e. in small abattoirs or during on-farm slaughter. Indeed, hazards applicable to a specific stunning method may occur in all situations where this method is applied (e.g. shackling in the case of waterbath), whereas some other hazards may not apply in certain circumstances, e.g. the ones specific to the arrival or unloading of containers in on-farm slaughter.

¹⁶ POULTRY definition by OIE: means all domesticated birds, including backyard poultry, used for the production of *meat* or eggs for consumption, for the production of other commercial products, for restocking supplies of game or for breeding these categories of birds, as well as fighting cocks used for any purpose.

Birds that are kept in captivity for any reason other than those reasons referred to in the preceding paragraph, including those that are kept for shows, races, exhibitions, competitions or for breeding or selling these categories of birds as well as pet birds, are not considered to be poultry. (Ref. Glossary of the 2018 © OIE – Terrestrial Animal Health Code – 10/8/2018).

¹⁷ Council Regulation (EC) No 1099/2009 of 24 September 2009 on the protection of animals at the time of killing. OJ L 303, 18.11.2009, pp. 1–30.

Additionally, it is to be noted that the mandate does not specify the level of detail to be considered for the definition of 'hazard'. One hazard could be subdivided into multiple ones depending on the chosen level of detail. For example, the hazard 'inappropriate electrical parameters' for electrical stunning methods, could be further subdivided into 'wrong choice of electrical parameters or equipment', 'poor or lack of calibration', 'voltage/current applied is too low', 'frequency applied is too high for the amount of current delivered'. For this opinion, it was agreed to define hazards by a broad level of detail ('inappropriate electrical parameters' in the example above).

The mandate also asks to define qualitative or measurable (quantitative) criteria to assess performance (i.e. consequences) on animal welfare (ABMs; ToR-2). This ToR has been addressed by identifying the negative consequences on welfare (so-called welfare consequences) occurring to the birds due to the identified hazards and the relevant ABMs that can be used to assess the welfare consequences qualitatively and/or quantitatively. In some circumstances, it might be that no ABMs exist or are not feasible to use in the context of slaughtering of birds; in these cases, emphasis to the relevant measures to prevent the hazards or to mitigate the welfare consequences will be given.

Birds experience welfare consequences due to the presence of hazards only when they are conscious, which apply in all birds during the pre-stunning phase. In the stunning phase, birds may experience welfare consequences if hazards occur during restraint (when restrained before stunning), if induction of unconsciousness is not immediate, or if stunning is ineffective. During bleeding following stunning, birds will experience welfare consequences in cases of persistence of consciousness or if they recover consciousness after stunning and before death. When birds are slaughtered without stunning, all the birds will experience the welfare consequences related to the hazards they are subjected to.

In this opinion, in the description of the processes of each phase, the relevant welfare consequences that the birds can experience when exposed to hazards will be reported. In this respect, it is to be noted that the mandate does not request the ranking of the identified hazards in terms of severity, magnitude or frequency of the welfare consequences that they can cause.

This opinion will also propose preventive and corrective measures that can be put in place by the person responsible for the slaughtering in order to prevent or correct the identified hazards. These measures will fall into two main categories: (1) structural and (2) managerial (ToR-3). When corrective measures for the hazards are not available or feasible to put in place, actions to mitigate the welfare consequences caused by the identified hazards will be discussed. In addition, it will be assessed whether specific categories or species of domestic birds might be subjected to specific hazards (ToR-4).

In response to an additional request from the European Commission, measures to mitigate the welfare consequences will also be described under ToR-2.

As this opinion will be used by the European Commission to address the OIE standards, it will consider more methods for slaughter than those reported in Council Regulation (EC) No 1099/2009.

Among the methods that are used for slaughter worldwide, EFSA has applied the following criteria for the selection of methods to include in this assessment: (a) all methods known to the experts that have technical specifications, i.e. not limited to the methods described in Council Regulation (EC) No 1099/2009, and (b) methods currently used for slaughter of birds, and those which are still under development but are likely to become commercially applicable, and (c) methods for which the welfare aspects (in terms of welfare hazards, welfare consequences, ABMs, preventive and corrective measures) are sufficiently described in the scientific literature.

Applying these criteria in this opinion will result in some practices that may be applied worldwide being neither included nor described.

The mandate also requests a list of unacceptable methods, procedures or practices that need to be analysed in terms of the above welfare aspects. The Panel considers that there are two problems with this request. Firstly, the question of what practices are acceptable or unacceptable cannot be answered by scientific risk assessment, but rather involves e.g. ethical and socio-economic considerations that need to be weighed by the risk managers. Secondly, it has to be noted that methods, procedures or practices cannot be subjected to a risk assessment procedure if there is no published scientific evidence relating to them. In the light of this, chapter 7.5.10 of the OIE Terrestrial Animal Health Code (OIE, 2018) lists principles and practices it considers unacceptable, and the Panel has no scientific arguments to disagree with these statements.

2. Data and methodologies

2.1. Data

2.1.1. Data from literature

Information from the papers selected as relevant from the literature search (LS) described in Section 2.2.1 and from additional literature identified by the working group (WG) experts was used for a narrative description and assessment to address ToRs 1, 2, 3 and 4 (see relevant sections in the chapter on Assessment).

2.1.2. Data from Member States and expert opinion

Information on the identification of hazards for poultry at slaughter existing in the EU Member States (MSs) was requested by EFSA to the National Contact Points (NCPs) for Council Regulation (EC) No 1099/2009 Network representatives¹⁸ (see Section 2.2.2).

The data obtained from the literature and network (mainly on the hazards) were complemented by the WG experts' opinion in order to identify the origins of hazards, welfare consequences, ABMs, and hazard preventive and corrective measures relevant to the current assessment.

2.2. Methodologies

To address the questions formulated by the European Commission in ToRs 1–4, three main approaches were used to develop this opinion: (i) literature search and (ii) consultation with MSs' representatives, followed by (iii) expert opinion through WG discussion. These methodologies were used to address the mandate extensively (see relevant sections in the Assessment chapter) and also in a concise way with the development of outcome tables (see Section 2.2.3.1).

The general principle adopted in the preparation of this opinion was that relevant reference(s) would be cited in the text when published scientific literature is available, and expert opinion would be used when no published scientific literature was available or to complete the results retrieved.

2.2.1. Literature search

A broad LS under the framework of 'welfare of poultry at slaughter and killing' was carried out to identify peer-reviewed scientific evidence providing information on the elements requested by the ToRs, i.e. description of the processes, identification of welfare hazards, origin, preventive and corrective measures, welfare consequences and related ABMs.

Restrictions were applied in relation to the date of publication, considering only those records published after a previous EFSA Scientific opinion on the topic (EFSA, 2004).

The search yielded a total of 412 records that were screened for their relevance to two topics: 'slaughter of poultry' and 'on-farm killing of poultry'. This screening produced 69 relevant records of which 50 pertained to 'slaughter of poultry'.

Full details of the LS protocol, strategies and results, including the number of the records that underpin each process, are provided in Appendix A to this opinion.

In addition, the reference list of relevant review articles and key reports were checked for further relevant articles, and experts were invited to propose any additional relevant publications, including ones published before 2004 when considered very important.

2.2.2. Consultation of MSs' representatives

The representatives of the EU Member States' (MSs) organisations designated as National Contact Points (NCPs) for Council Regulation (EC) No 1099/2009 are members of the EFSA AHAW Network on 'NCP under art. 20 of Council Regulation (EC) No 1099/2009' (NCP Network). The NCP Network meets once a year to facilitate exchange of information and sharing of best practices among NCPs. At the NCP Network meeting held in October 2018, an exercise was held aiming at the identification and ranking of hazards for poultry at slaughter.

During this meeting, hazards for each process of slaughtering were identified and presented to the NCPs. A discussion was held to agree on the terminology for the common understanding of the

¹⁸ <https://www.efsa.europa.eu/en/animal-health-and-welfare/networks>

hazards. Finally, for each phase, NCPs were asked to vote, through an online application, for the hazards that were present in their countries. (For details, see EFSA, 2018).

The resulting ranking gave an indication of the hazards that are most common in EU MSs and are considered by national authorities as the most urgent to be addressed in order to safeguard animal welfare during slaughtering of poultry.

2.2.3. Expert opinion through working group discussion

The WG experts first described the phases and the related processes of slaughter and specifically which stunning/killing methods should be considered for the current assessment.

Using the available literature and their own knowledge, the experts then produced a list containing the possible welfare hazards characterising each process related to the slaughter of poultry. To address the ToRs, the experts then identified the origin of each hazard (ToR-1) and the related preventive and corrective measures (ToR-3) along with the possible welfare consequences of the hazards and relevant ABMs (ToR-2). Measures to mitigate the welfare consequences were also considered.

It is to be noted that ToR-1 of the mandate asks to identify the origins of the hazards in terms of staff or facilities/equipment. When discussing the origins, it was considered necessary to explain them further by detailing what actions of the staff or features of the equipment and facilities can cause the hazard. Therefore, for each origin category (staff, facilities/equipment), relevant origin specifications have been identified by expert opinion.

2.2.3.1. Development of outcome tables to answer the ToRs

A conceptual model was developed following EFSA's guidance on risk assessment in animal welfare (EFSA AHAW Panel, 2012a) that shows the interrelationships between elements corresponding to the different ToRs (see Figure 1), and the main results of the current assessment are summarised in tables (so-called outcome tables, see Section 3.10).

The outcome tables link all the mentioned elements requested by ToRs 1, 2 and 3 of the mandate and provide an overall outcome for each process of slaughter in which all retrieved information is presented concisely (see description of the structure below and, for details, Tables 9–21). Conclusions and recommendations of this scientific opinion are mainly based on the outcome tables.

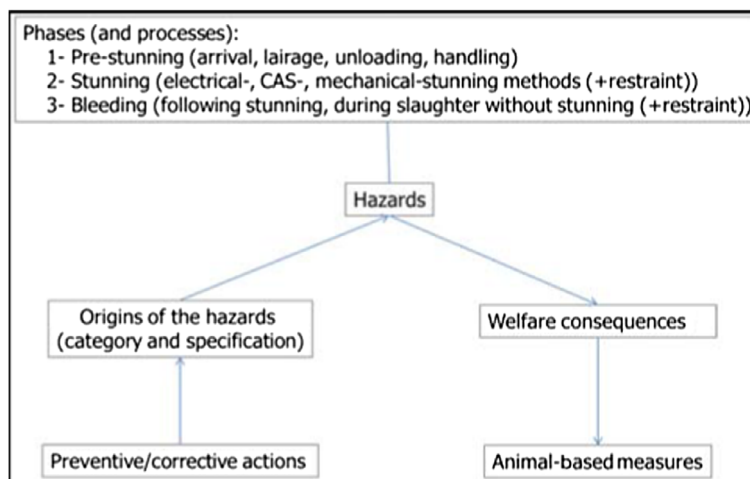


Figure 1: Conceptual model showing interrelationships between the elements corresponding to the different ToRs

Description of the structure of the outcome tables

Outcome tables were developed and include summarised information linking all the elements analysed in response to the terms of reference of the opinion – i.e. hazards, welfare consequences, relevant ABMs, hazard origins, preventive and corrective actions.

The outcome tables have the following structure and terminology:

- **OUTCOME TABLE:** Each table represents the summarised information for each poultry slaughter process (see Sections 3.1–3.3.2).

- **HAZARD:** the first column in each table reports all hazards pertaining to the specific process; the number of the section where each hazard is described in detail is reported in brackets.
- **ROW:** For each hazard, the individual row represents the summarised information relevant to the elements analysed for that hazard. Therefore, it links between an identified hazard, the relevant welfare consequences, origin/s of hazards and preventive and corrective measures (see example in Figure 2).
- **WELFARE CONSEQUENCES OCCURRING TO THE BIRDS DUE TO THE HAZARD:** this column lists the welfare consequences to the birds of the mentioned hazards.
- **HAZARD ORIGIN:** this column contains the information related to the main origin of the hazard, which can be staff-, equipment- or facility-related. Most hazards can have more than one origin.
- **HAZARD ORIGIN SPECIFICATION:** this column further specifies the origin of the hazard. This information is needed to understand and choose among the proposed preventive and corrective measures.
- **PREVENTIVE MEASURE/S FOR THE HAZARD:** depending on the hazard origin/s, several measures to prevent the hazard are proposed in this column. They are also elements for implementing standard operating procedures (SOP).
- **CORRECTIVE MEASURE/S FOR THE HAZARDS:** in this column, practical actions/measures for correction of the mentioned hazards are proposed. These actions relate to the identified origin of the hazards.
- **ANIMAL-BASED MEASURES:** this row lists the feasible measures to be performed on the birds to assess the welfare consequences of a hazard.

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for the hazard (implementation of SOP)	Corrective measure/s for the hazard
(Number of section)					
ABMs: (to assess the identified welfare consequences)					

Figure 2: Structure of outcome table (for details on the data, see Tables 9–21)

2.2.4. Uncertainty analysis

The outcome tables include qualitative information on the hazards and related elements identified through the methodologies explained in Section 2.2.

When considering the outcome tables, uncertainty exists at two levels: (i) related to the completeness of the information presented in the table, namely to the number of rows within a table (i.e. hazard identification) and (ii) related to the information presented within a row of the table (i.e. completeness of hazard origins, preventive and corrective measures on the one side, and welfare consequences and ABMs on the other side).

However, owing to the limited time available to develop this scientific opinion, there will not be an uncertainty analysis for the latter level, but only for the first level, i.e. for the hazard identification.

In such a process of hazard identification, uncertainties may result in false-negative or false-positive hazard identifications:

- **Incompleteness (false negative):** Some welfare-related hazards may be missed in the identification process and so would be considered non-existent or not relevant.
- **Misclassified (false positive):** Some welfare-related hazards may be wrongly included in the list of hazards of an outcome table without being a relevant hazard.

Incompleteness (false negatives) can lead to under-estimation of the hazards with a potential to cause (negative) welfare consequences.

The uncertainty analysis was limited to the quantification of the probability of false-negative or false-positive hazards. False-negative hazards can relate to (i) the situation under assessment, i.e.

limited to the slaughter practices considered in this assessment according to the three criteria described in the Interpretation of ToRs (see Section 1.2), or (ii) the global situation, i.e. including all possible variations to the slaughter practices that are employed in the world and that might be unknown to the experts of the WG. The Panel agreed it was relevant to distinguish the false-negative hazard identification analysis for these two cases.

For false-negative hazard identification, the experts elicited the probability that at least one hazard was missed in the outcome table. For false-positive hazard identification, the experts elicited the probability that each hazard included in the outcome table was correctly included.

For the elicitation the experts used the approximate probability scale (see Table 1) proposed in the EFSA uncertainty guidance (EFSA, 2019). Individual answers were then discussed, and a consensus judgement was obtained.

A qualitative translation of the outcome of the uncertainty assessment was also derived (e.g. 'extremely unlikely' for an uncertainty of 1–5%, see Table 1).

Table 1: Approximate probability scale (see EFSA, 2019, Table 4)

Probability term	Subjective probability range	Additional options	
Almost certain	99–100%	More likely than not: > 50%	Unable to give any probability: range is 0–100%
Extremely likely	95–99%		
Very likely	90–95%		
Likely	66–90%		
About as likely as not	33–66%		Report as 'inconclusive', 'cannot conclude', or 'unknown'
Unlikely	10–33%		
Very unlikely	5–10%		
Extremely unlikely	1–5%		
Almost impossible	0–1%		

3. Assessment

In Sections 3.1, 3.2 and 3.3, for each phase of slaughtering, the relevant processes are described in detail following this structure (see Figure 3): (a) process description, with information on how it is technically and practically carried out and how the birds are kept (e.g. if still in containers or in a restraint device, etc.); (b) a section on related hazards and welfare consequences where, in order to explain the impact of each process on the birds' welfare, a list is provided of the main hazards that have been identified to occur during the process along with their relevant welfare consequences. In some specific cases, ABMs are also provided as examples; and (c) assessment of animal welfare, with a brief description of the key points for assessing welfare of poultry.

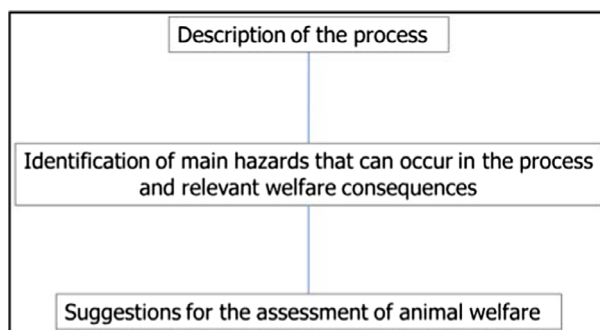


Figure 3: Structure of the sections on the processes assessed in this scientific opinion (Sections 3.1.1–3.3.2)

Section 3.5 deals with the unacceptability on welfare grounds of methods, procedures or practices.

Details of the hazard's characterisation and origins (ToR-1) and a description of the appropriate preventive and corrective measures (ToR-3) are discussed in Section 3.6; a description of the welfare consequences, the related ABMs (ToR-2) and of the measures to mitigate the welfare consequences is provided in Section 3.7. The preventive measures (ToR-3) that are considered general and applicable to several hazards and processes are presented in Section 3.8. Hazards for specific animal categories (ToR-4) are reported in Section 3.9.

Finally, outcome tables linking the above-mentioned elements requested in the ToRs of the mandate are reported in Section 3.10.

3.1. Description of Phase 1: pre-stunning and relevant welfare consequences

The pre-stunning phase includes four processes: arrival, unloading of containers from the truck, lairage, and handling and removing of birds from the containers. These processes are described in Sections 3.1.1–3.1.4. The outcome tables related to each process are reported in Section 3.10.1 (Tables 9–12).

It is well known that preslaughter feed withdrawal time, heat stress, struggle during handling and shackling, and shackle duration adversely affect welfare as well as carcass and meat quality (Ali et al., 2008).

The preslaughter phase has potentially important animal welfare implications (Medina-Vara et al., 2016), which are usually measured by dead on arrival (DoA) at the slaughterhouse (Jacobs et al., 2017; for details, see Section 3.7.2). In Canada, Caffrey et al. (2017) investigated the effect of transport of broilers for long distances and being exposed to environmental factors such as cold temperatures, by assessing the percentage of DoAs. Analysis of the data revealed that most of the variation in mortality risk occurred at the load level rather than at the producer or barn level. There were significant effects of bird sex, age and weight, catching team, journey duration and holding barn duration on mortality risk. The following environmental risk factors increased mortality risk: cold temperatures during the journey and in the holding barn, low crate stocking density during journeys at cold temperature and increased trailer temperature when in the holding barn. The analyses identified risk factors that can be used to refine management practices to mitigate some of the mortality risk. Increased mortality in some loads was associated with environmental conditions that caused deaths from hypothermia, whereas in other circumstances, some deaths likely occurred from hyperthermia. The climatic conditions in Atlantic Canada were responsible for significant risk factors that affected the mortality risk. Although refinement of the management practices described in this study – such as reduced journey and lairage durations, and increased crate stocking density – can mitigate some of the mortality risk. The extreme cold conditions experienced during some parts of the year exceeded the capacity of the transportation systems to provide environmental conditions that minimise mortality. In addition, Chauvin et al. (2011) collected data in France regarding animal characteristics and rearing, catching, transport and lairage conditions on the farm and at the slaughterhouse for 404 chicken broiler flocks processed during 2005. Multivariable analysis of data indicated that the average prevalence of DoA was 0.18% (from 0% to 1.4%). Variables found to be associated with the prevalence of DoA were flock cumulative mortality on the farm, the catching system (mechanical being more risky than manual), the density in crates (more space allowance being associated with less mortality) and climatic conditions (rain and wind being associated with higher risk of DoA). It was concluded that mortality during transport is related to all production steps from the farm to the slaughterhouse. Petracci et al. (2006) surveyed the prevalence of DoA birds in over 33 broiler, 11 turkey, and 19 spent-hen abattoirs representing the majority (around 70%) of Italian poultry slaughter plants. The overall average prevalence of DoA was found to be 0.35, 0.38 and 1.22% in broilers, turkeys, and spent hens, respectively. The season significantly ($p \leq 0.01$) influenced the mortality of all poultry categories considered, with the highest prevalence being observed during the summer (0.47, 0.52 and 1.62% for broilers, turkeys and spent layers, respectively).

3.1.1. Arrival

Process description

Arrival of poultry at a slaughterhouse is the first process of slaughtering and it takes place from the moment the truck arrives at the slaughterhouse until the moment the containers are unloaded from the truck.

The condition of birds at arrival represents the cumulative result of the state of animals on the farm including husbandry conditions, catching, crating of birds and transport in the truck.

Related hazards and welfare consequences

Consider that:

- birds before being transported have been deprived of food (and sometimes water) for a variable duration;
- birds arriving at the slaughterhouse have been submitted to transportation under variable macro- and microclimatic conditions, durations and conditions within the containers (e.g. stocking densities);
- birds should be unloaded from the truck as soon as possible but may remain on the truck for some time under adverse climatic conditions before unloading.

Consequently, during arrival, birds can be submitted to effective temperatures that are too high or too low, have insufficient space allowance and have been deprived of food and water for too long (for detailed description of these hazards, see Section 3.6.1). The welfare consequences (for details see Section 3.7.1) that can be caused by these hazards (that will not apply all at the same time) are: cold or heat stress, restriction of movement and/or prolonged hunger and thirst.

The hazards identified at arrival, relevant welfare consequences and related ABMs, origins of hazards, preventive and corrective measures are reported in Table 9.

Assessment of animal welfare

In the literature, arrival is rarely distinguished from transport or lairage; therefore, no specific data are available for this specific process.

In the EU, according to Council Regulation (EC) No 1099/2009, the Food Business Operator (FBO) has the overall responsibility for the welfare of animals from the time of arrival at the slaughterhouse until the animals are dead. Based on this sound principle, assessment of welfare state at the time of reception of animals at the place of slaughter should be considered as a prerequisite and an important first step in fulfilling animal protection. Such an assessment protocol would certainly enable the responsible person to decide upon appropriate corrective actions for alleviating further negative welfare consequences (see details in Section 3.7.1) or immediate stunning and slaughter of animals as an ultimate intervention. For example, if a considerable proportion of birds on the transport truck are showing signs of heat stress (e.g. panting (for detail about AMBs, see Section 3.7.2)) due to unexpected weather conditions or the animals have been subjected to prolonged periods of hunger or thirst due to unexpected road conditions (e.g. traffic jam or road diversions), this should be dealt with appropriately.

3.1.2. Unloading from the truck

Process description

Following arrival at the slaughterhouse, poultry in the containers can be either kept in lairage on the truck or unloaded and moved to designated areas. The procedure commonly used in Europe is that the containers are unloaded as soon as possible. Unloading is the action of taking out the containers (or crates) of poultry from the truck mechanically (forklift) or manually and placing them in the lairage area where they can stay until the time of slaughter (see Figure 4).

Commercial practices vary from unloading of animals and moving them straight to the point of stunning without lairage, to holding them in lairage for some hours depending upon the throughput rate and other operational factors.

Related hazards and welfare consequences

Grilli et al. (2015) explained that unloading animals as quickly as possible after arrival at the slaughter plant can prevent negative welfare consequences. Containers in good condition without broken plastic or metal parts protruding inwards reduce the possibility of injuries and bruises.

In drawer systems, a common problem is head entrapment. This is caused by rough loading on the farm or unloading in the slaughterhouse or/and poor design of the drawer rack (AVMA, 2016). The hazards 'rough handling of the containers' and 'jamming or crushing heads and legs in containers' can both appear at this stage and lead to pain and fear.

The hazards identified during unloading, relevant welfare consequences and related ABMs, origins of hazards, preventive and corrective measures are reported in Table 10.

Assessment of animal welfare

Animal welfare is not easy to assess during the process of unloading. Attention should be paid to any part of the bird that could be visible and/or jammed or crushed. The responsible person of the slaughterhouse should immediately apply measures to mitigate or stop negative animal welfare consequences, e.g. kill the animal as soon as possible.



Figure 4: Unloading of crates from the truck. Source: kindly provided by Berg C

3.1.3. Lairage

Process description

According to Council Regulation (EC) No 1099/2009, lairaging means keeping animals in stalls, pens, covered areas or fields associated with or part of slaughterhouse operations. This definition has been very widely accepted.

The lairage is the period in between the entry of the animals into the lairage area (either on or unloaded off the truck) until they are taken out of the containers (which is the next process – handling and removing of birds from crates or containers) or the containers are moved (for the controlled atmosphere stunning (CAS) system). When unloaded, the containers are stacked in the lairage area where they can stay several hours.

Containers are placed on top of each other. To prevent lower level animals being soiled by the faeces of the birds above, it is preferable to use containers with unperforated floors. However, in countries where the temperature and humidity are high, the poultry industry uses containers with perforated floors to facilitate the movement of air and improve the welfare status of the birds.

The time that animals spend during lairage can be very variable. In Italy, Grilli et al. (2015) estimated this time for 233 different batches of broilers as ranging between 0.2 and 9.4 h with a mean of 4 h. A Belgian study (Jacobs et al., 2016) undertaken in six slaughter plants, found lairage durations from 15 to 555 min (9.3 h), with a mean at 275 min (4 h 35 min) for broiler chickens. Lairage for 3–4 h in a controlled lairage environment during the summer and spring is considered as necessary to reduce the thermal load of broiler chickens (Vieira et al., 2011a). In Brazil, Rodrigues et al. (2017) investigated the effects of different lairage times and the position of chicken crates during transport to the slaughterhouse on the biochemical and haematological profile. They found an increase in the heterophil/lymphocyte (H/L) ratio in birds that were subjected to 6 h of lairage at the abattoir. This indicates that increasing the preslaughter lairage and fasting period generates stress-related metabolic disorders in broiler chickens. In Brazil, Vieira et al. (2010) evaluated 215 poultry transport trucks from a commercial poultry slaughterhouse from 2006 to 2007. Data were obtained from the holding area acclimatised by fans and water misting in the mornings, afternoons and at night. The

thermal variables (temperature and relative humidity (RH)), distance, lairage time and density of birds per cage were considered in the analysis. The results indicated that the effects of distance and lairage time were important in the variation of rectal temperature and on the number of dead birds per truck.

Vieira et al. (2011a) evaluated preslaughter data from 13,937 broiler flocks recorded daily during 2006 in a commercial slaughterhouse in south-eastern Brazil. The main factors that influenced daily mortality rate were mean dry bulb temperature and RH, lairage time, daily periods, density of broilers per crate, season of the year, stocking density per lorry, transport time, and distance between farm and slaughterhouse. Season was found to have significant effects ($p < 0.05$) on average mortality rates. The highest risk was observed in summer (0.42%), followed by spring (0.39%), winter (0.28%), and autumn (0.23%). A decrease in preslaughter mortality of broilers during summer ($p < 0.05$) was observed when the lairage time was increased, mainly after 1 h of exposure to a controlled environment. Thus, lairage for 3–4 h in a controlled lairage environment during the summer and spring is necessary to reduce the thermal load of broiler chickens. Vieira et al. (2011b) conducted another study on data from 2006 for a commercial poultry abattoir in the State of Sao Paulo, Brazil. The historical data on broiler mortality during preslaughter operations for 13,937 trucks was given by the abattoir. Analysis of the data revealed that the DoA recorded during 1–3 h lairage increased with increasing environmental temperature (22 to above 29°C).

Villaruel et al. (2018) applied a multivariable linear model to analyse the prevalence of DoA over one year in 1,856 flocks of Ross broilers (9,188 shipments). The overall percentage of DoA was 0.187%, and the effect of the daily maximum outside temperature on DoA was quadratic, with minimum DoA at 21.5°C. Arrival time to the slaughterhouse and waiting time increased DoA by 0.0044% and 0.0021%, respectively, for every 60 min increase. DoA was higher in males (which were heavier than females), and in flocks that were previously thinned.

Related hazards and welfare consequences

In the lairage area, temperature variation can be significant and depend on the time of day and the season. Temperature and humidity can be registered at the crate level, and recording systems can monitor the climatic conditions in the area and allow alarm warning when the values are outside the thermoneutrality zone of the birds (15–25°C and 60–65% humidity).

Considering the climatic conditions and the waiting times to which the animals have been submitted during transport and lairage, the hazards identified during this process are: 'too high or too low effective temperature', 'too long food and water deprivation', 'unexpected loud noise', and 'insufficient space allowance'. These hazards can cause heat or cold stress, prolonged hunger, prolonged thirst, fear and restriction of movements, as welfare consequences to the birds.

The hazards identified at 'lairage', relevant welfare consequences and related ABMs, origin of hazards, preventive and corrective measures are reported in Table 11.

Assessment of animal welfare

The containers are arranged in spaced rows (Figure 5) so that there is a human passage is possible between the rows to allow observation of the animals. This arrangement also allows air to circulate between the containers to ensure good ventilation of the birds. Birds usually stay at lairage for several hours (see previous section), which allows the responsible person at the slaughterhouse and official inspectors to assess the birds' welfare and health. Welfare inspection can be done using the AMBs described in Section 3.7.2.



Figure 5: Lairage zone at poultry slaughterhouse. Source: Federation of French Poultry Industries (FIA)

3.1.4. Handling and removing of birds from crates or containers

Process description

Handling refers to removal of birds from the containers for the purpose of restraining, stunning and slaughtering them.



Figure 6: Most common types of cages and containers used for the transport of poultry: a.1 and a.2: Plastic poultry crate with top opening or top and side opening, depending on model; b: Containers with front and side access; c.1 and c.2: Containers with plastic drawers that slide (source: Avipôle Formation)

Different types of containers exist (Figure 6) and their design, mainly the shape of the door or drawer opening, has an impact on the ease of manually removing the birds from the containers.

For gas stunning in containers, the containers are moved mechanically from the lairage area to the gassing chamber where the birds will be removed (for details, see Section 3.2.2).

If a drawer system or individual cages are used for processing birds with electrical stunning (see Figures 6 a.1, a.2, c.1 and c.2), the drawers or coops are removed from the palletised rack either manually or with automated equipment. They are placed on a conveyor that runs into the shackle room. Handlers pick up each individual bird and hang it on the shackle line.

Related hazards and welfare consequences

The design of some of these cages (Figures 6 a.1 and a.2) may cause animal welfare problems as the opening for catching animals may be too narrow, increasing the risk of injury when handling the animal. Similarly, catching poultry located away from the openings can be complicated, and the operator may tend to catch the animal roughly by the head, neck or wings, increasing the risk of injury. One of the most common transport modules in Europe consists of a frame with movable floors to ease the loading (Figure 6b). If a dump module system is used (Figure 6b), a hydraulic platform operated by an employee tilts the entire palletised container to dump the live birds onto a conveyor that runs into the shackle room (Tinker et al., 2005). Handlers pick up live birds and hang them on the shackle line. One problem that can occur with dump modules is unloading the birds too fast. This results in bunching on the conveyor belts, pileups and excess birds falling off the conveyor with the risk of having free birds on the premises. Broken wings are more likely to occur when heavier birds are unloaded from the dump modules, compared with lighter birds (AVMA, 2016).

The hazards identified during this process are 'rough handling of the birds during removal from the containers' and 'tipping or dumping on the conveyors' or 'bunching of birds on the conveyor belt'. These hazards can expose the birds to pain and fear.

The hazards identified during 'handling', relevant welfare consequences and related ABMs, origin of hazards, and preventive and corrective measures are reported in Table 12.

Assessment of animal welfare

During this process, birds are removed from the containers; this is a key stage where dead birds are removed (and DoA can be assessed). Moreover, runts (small birds) that, e.g. in the case of waterbath, would miss the stunner, and injured birds (e.g. with dislocated or broken wings/bones) need to be identified and killed before shackling them.

3.2. Description of Phase 2: stunning and relevant welfare consequences

General description of stunning methods

The stunning phase includes stunning methods and relevant restraint practices.

According to Council Regulation (EC) No 1099/2009, 'restraint' means the application to an animal of any procedure designed to restrict its movements sparing any avoidable pain, fear or agitation in order to facilitate effective stunning and killing; whereas 'stunning' is any intentionally induced process which causes loss of consciousness and sensibility without pain, including any process resulting in instantaneous death.

The main stunning methods employed in the slaughter of poultry: (1) electrical, (2) controlled atmospheres and (3) Mechanical. The latter are normally used as back-up methods. These methods are described in Sections 3.2.1–3.2.3; the outcome table relevant to each method is reported in Section 3.10.2 (Tables 13–19).

Electrical and mechanical stunning methods require some form of restraint to facilitate proper application. In the following sections, the stunning method will be described along with the specific restraint used. CAS is performed with no form of restraint: the birds arrive at the slaughterhouse in containers and are passed through a chamber containing the appropriate gas mixture. Alternatively, birds tipped automatically out of transport containers on to a conveyor belt are also be passed through a chamber containing gas mixtures.

Related hazards and welfare consequences

Stunning methods have welfare advantages and disadvantages (for a review, see Berg and Raj, 2015) and the details of the hazards and welfare consequences identified for each method are described in Sections 3.6 and 3.7; however, in general, it can be noted that:

- Two categories of hazards exist regarding stunning methods: (i) those leading to negative welfare consequences during induction of unconsciousness (before animals lose consciousness); and (ii) those resulting from delay in or failure to achieve loss of consciousness. This last category leads to birds being conscious and therefore exposed to the hazards characterising the restraint and bleeding phases (e.g. birds being neck-cut while conscious).
- Hazards due to the restraint cause negative welfare consequence when the birds are conscious during restraining.

Conscious animals have the capacity to receive, process and respond to information from internal and external environments, whereas effective stunning leads to a brain state that is incompatible with this capacity and persistence of consciousness (EFSA, 2004). Achieving effective stunning by any method relies on certain key parameters (see EFSA AHAW Panel, 2013), and ineffective stunning will lead to persistence of consciousness during neck cutting, or recovery of consciousness during bleeding. Both these situations are very painful and fearful for animals; therefore, they should be avoided.

Although direct scientific evidence is lacking, recovery of consciousness following effective stunning can be a painful process. For example, electrical waterbath stunning of poultry involves passage of current through the whole body, which induces tonic seizures (state of tetanus), and this, in association with a direct electrical stimulation of pectoral muscles, is known to cause, depending upon the electrical stunning parameters, muscle bruising and broken pectoral bones in a portion of the birds. Similarly, exposure to gas mixtures causes clonic seizures (wing flapping) in unconscious poultry, which can lead to dislocation of joints and fracture of wing bones in a portion of the birds (Raj, 1999). In addition, exposure of animals to an atmosphere of high carbon dioxide concentration induces unconsciousness by lowering of blood pH from 7.4 to 6.7, a state of metabolic acidosis; recovery from this state can be distressing, if not painful (Engelking, 2015).

Assessment of animal welfare

For what has been described above, it is crucial that, after stunning, birds are checked for unconsciousness by assessing indicators of consciousness/unconsciousness at key stages (EFSA AHAW Panel, 2013). In cases of consciousness, appropriate measures should be put in place (see Section 3.7.1). However, in certain circumstances, e.g. in slaughterhouses using electrical stunning, line speeds faster than 8,000 birds per hour (more than 2 birds per second) do not always allow for the application of any intervention after stunning. In these cases, it may happen that animals fit for the normal slaughter line suffer when stunning procedures fail. To avoid this, appropriate back-up stunning equipment should be available on the spot to be used in cases of failure of the stunning equipment initially used. The back-up method may differ from the one used first.

3.2.1. Electrical stunning methods (including restraint)

Three electrical stunning methods exist: (a) waterbath, (b) head-only and (c) head-to body. However, in practice, only the first two are reported in the scientific literature for slaughtering birds and will be described in this opinion.

Considerations on restraint

Electrical waterbath and head-only electrical stunning of poultry differ from the stunning of red meat animal species in that the live birds are hung upside down by the legs in shackles on a conveyor prior to stunning and slaughter (see Figure 7). According to Gentle and Tilston (2000), shackling of poultry involves the insertion of each leg into parallel metal slots by shacklers and holding the bird inverted for a period of time before stunning and slaughter; this causes pain and fear. The pain due to shackling is likely to be worse in birds with leg abnormalities (e.g. lame broilers) (Butterworth, 1999; Danbury et al., 2000).

However, when poultry are slaughtered in small slaughterhouses by head-only electrical stunning, birds may be placed inverted in a cone or restraint by hand. This process involves inversion but not leg shackling.

3.2.1.1. Waterbath

Process description

Waterbath stunning is based on the principle that an electric current of a sufficient minimum amperage is passed from an electrified waterbath through the head and body of the birds to the metal shackles from which the birds are hung by the legs. This current causes generalised epileptiform activity in the birds' brains, rendering them reversibly unconscious (Berg and Raj, 2015). The effectiveness of water-bath stunning is determined by the waveform (alternating current (AC) or pulsed direct current), frequency (Hz) and amount (mA) of current delivered to birds (Raj, 2006). Depending on the electrical frequency, the current may also affect the heart of the bird, causing permanent cardiac arrest, in which case the stunning is irreversible. It should be mentioned that there is a wide range of current levels, waveforms and frequencies used commercially, and that there is a complex relationship between these input variables (Berg and Raj, 2015).

In general, the effectiveness of electrical waterbath stunning is determined by the waveform (bipolar alternating or unipolar pulses) of current, frequency (Hz) of current and the amount of current (Amp) delivered to individual birds in the bath (see EFSA, 2004 for details). Certain minimum currents relevant to different frequency ranges have been stipulated in Council Regulation (EC) No 1099/2009 and OIE Guidelines (OIE, 2016; see Table 2).

Table 2: Minimum average currents for waterbath stunning of poultry (from Council Regulation (EC) No 1099/2009 and OIE, 2019 – Chapter 7.5)

Frequency (Hz)	Chickens	Turkeys	Ducks and geese	Quails
< 200 Hz	100 mA	250 mA	130 mA	45 mA
From 200 to 400 Hz	150 mA	400 mA	Not permitted	Not permitted
From 400 to 1,500 Hz	200 mA	400 mA	Not permitted	Not permitted

The exposure time must be at least 4 s, but commonly exposure times in commercial abattoirs are considerably longer than this, partly to ensure that no birds manage to keep their head up during the entire w passage and thereby evade stunning.

However, Raj et al. (2006a) investigated the effectiveness of electrical waterbath stunning of individual broilers for 1 s with a constant root mean square (RMS) currents of 100, 150 or 200 mA, delivered using a variable voltage/constant current stunner with 200, 400, 600, 800, 1,000, 1,200 or 1,400 Hz sine wave AC. Based on the results of this study, it was recommended that effective waterbath stunning of broilers with a minimum constant current of 100, 150 and 200 mA could be achieved with electrical frequencies of up to 200, 600 and 800 Hz, respectively. In addition, it was suggested that electrical frequencies of above 800 Hz would require a minimum current greater than 200 mA to induce epileptiform activity in the electroencephalograms (EEGs) of broilers.

From the results of Raj et al. (2006b,c), it can be extracted that (a) use of sine wave AC is better than pulsed direct current; (b) the minimum current required to achieving effective stunning varies with the frequency of the current; and (c) pulse width is critical when using pulsed direct current.

Girasole et al. (2015) evaluated the impact of waterbath stunning of broilers with different frequencies and current levels under slaughterhouse conditions and reported that all the experiments confirmed that high stunning frequencies induce a lower occurrence of lesions on carcasses but require greater current intensities to be effective. A frequency of 750 Hz and an average current intensity of 200 mA for each bird in the waterbath resulted as the best combination of electrical parameters to obtain proper stunning with no adverse consequence on meat quality.

In a more recent study using a multiple-bird waterbath stunner under slaughterhouse conditions, Girasole et al. (2016) investigated the effectiveness of stunning broilers with average RMS currents of 150, 200 and 250 mA and frequencies of 200, 400, 600, 800 and 1,200 Hz delivered using sinewave AC. Occurrence of the corneal reflex, spontaneous eye blinking, and a positive response to a painful stimulus were monitored and recorded as indicators of consciousness immediately after the stunning and at 20 s post-stun. The results indicated that, at a current level of 150 mA, the probability of a successful stun was over 90% at 200 Hz, approximately 40% at 400 Hz, and below 5% for frequencies greater than 600 Hz. Based on the results, the authors concluded that the minimum current necessary to achieve effective stunning in 90% of birds is 150 mA for 200 Hz, 200 mA for 400 Hz and 250 mA for 600 Hz. Stunning treatments at 1,200 Hz provided the lowest probability of a successful stun even at the highest current level tested. The implication of these results is that

frequencies of sinewave AC above 600 Hz would require RMS currents of more than 250 mA, which are yet to be established.

Regarding the elements discussed here, it appears that in broilers the better combination for optimised waterbath stunning is to use sine wave AC no higher than 600 Hz for a duration of 4 s minimum and with an average current such as described in Table 2. There is no scientific evidence that demonstrates that frequencies higher than 600 Hz with a current of 400 mA will cause effective stunning in turkeys. Therefore, it is opinion of the WG experts that the waterbath stunning electrical frequency of less than 600 Hz is the better than higher frequencies to ensure proper stunning also in turkeys.



Figure 7: Restraint of poultry prior to entering (A) and exiting (B) the multiple waterbath stunner. Source: kindly provided by Berg C

Related hazards and welfare consequences

The hazards identified during this process are: 'inversion', 'shackling', 'drops, curves and inclination of shackle line', 'inappropriate shackling', and 'pre-stun shocks', which are hazards that can cause pain and fear. Other hazards identified during this process are: 'poor electrical contact', 'too short exposure times', 'inappropriate electrical parameters' and 'inability to deliver minimum current to all the birds'. This second group of hazards can cause failure in onset of unconsciousness (consciousness) leading to pain and fear.

The hazards identified during 'waterbath stunning', relevant welfare consequences and related ABMs, origin of hazards, preventive and corrective measures are reported in Table 13.

Assessment of animal welfare

Electrical waterbath stunning is the most commonly used method for poultry. Routine monitoring of the welfare outcomes at key stages (see, EFSA AHAW Panel, 2013) is vital to ensuring protection of animals at the time of slaughter. However, high-throughput rates (e.g. 8,000 or more per hour, see introduction to Section 3.2) are not conducive to correct welfare monitoring and application of appropriate corrective measures, and prevention should therefore be the best policy. On the other hand, corrective measures are feasible with lower throughput rates. Most of the animal welfare Regulations and guidelines stipulate that a back-up stunning method should be applied; this measure mitigates the welfare consequences (see also Section 3.7.1).

Due to the complexity of multiple bird waterbath stunning (EFSA, 2004), it is very difficult to distinguish birds that are electrically immobilised but still conscious – a result of using inappropriate electrical stunning parameters – from those that are correctly rendered unconscious through use of appropriate parameters (EFSA AHAW Panel, 2012b). The indicators often applied when looking for signs of consciousness (which is a prerequisite for being able to experience pain and fear) in birds stunned using electrical waterbath, are absence of tonic seizures, presence of breathing, and spontaneous blinking. Also, vocalisation and eye reflexes can be included, and the presence of wing-flapping is a reliable indicator of consciousness (EFSA AHAW Panel, 2013; Grilli et al., 2015).

Deviation on the use of waterbath stunning

Inevitably, ineffective electrical stunning parameters would have serious welfare consequences. This concern is supported by several publications in the literature. For example, in a survey of 329 US

poultry plants, 92.1% reported using electrical stunning and 77.4% of those used low-voltage (10–25 V), high-frequency (500 Hz) systems (Heath et al., 1994). Another study involving two-phase electrical waterbath stunning, with a first phase consisting of low-voltage (12 and 15 V), high-frequency (550 Hz) pulsed direct current for 10 s and a second phase consisting of sinusoidal wave AC (50 Hz at 40, 50 and 60 V for 5 s) showed that 22% of the birds had corneal reflexes, 18% had spontaneous blinking, and < 10% had wing flapping (Prinz et al., 2012) that are considered as signs of consciousness and eventually pain and fear. The AVMA (2016) stated that it is unclear whether birds exposed in the waterbath to low currents delivered using high frequencies, as in the previous examples, truly reach a state of unconsciousness. In addition, these electrical stunning parameters are applied using plate or grid systems for electrical stunning of poultry (Canadian Food Inspection Agency, 2019¹⁹), in which the heads of birds are dragged on an electrified plate or grid and do not involve complete immersion of the birds' heads in the waterbath.

In addition, owing to the complexity of multiple-bird electrical waterbath stunning, it has been suggested that some birds subjected to waterbath stunning do not receive sufficient current to render them immediately unconscious (Wilkins et al., 1999). This problem is further confounded by the use of inappropriate electrical parameters for waterbath stunning. For example, it has been reported that when using an average current level of 44 mA per bird, only 36% of chickens had EEGs indicative of effective stunning after 4 s of exposure to the current (Schütt-Abraham et al., 1983). In another study, using a 50 Hz sine wave AC and testing several low current settings — including 45, 60 and 75 mA — currents below 75 mA failed to adequately stun birds after 4–5 s (Gregory and Wotton, 1990). Using a 350 Hz pulsed DC applied for 4 s, Gregory and Wotton (1991) showed that only 40% of birds were adequately stunned when the current level fell below 120 mA.

When birds are subjected to electrical waterbath stunning delivering inadequate currents, they may show seizures visually indistinguishable from effectively stunned birds, but without the manifestation of epileptiform activity in the EEGs. Exposure of birds to low currents for long durations will not render the birds unconscious, but they may not show any physical signs of consciousness. It is worth noting that the amount of current necessary to induce an epileptiform EEG is more than the amount necessary to induce seizures (Schütt-Abraham et al., 1983; Raj et al., 2006a,b,c). Observations of outward physical signs such as seizures and absence of physical reflexes, have led to the suggestion that some electrically stunned birds may not be unconscious following attempts to stun them in an electrified waterbath but are rather in a state of electrically induced paralysis or electro-immobilisation (Heath et al., 1981; Schütt-Abraham et al., 1983).

Electrical immobilisation of poultry would occur during waterbath stunning when the electrical parameters used for stunning do not induce immediate loss of consciousness indicating a generalised epileptiform activity in the brain (as demonstrated in laboratory studies using EEGs). When conscious birds are electrically immobilised, they will be prevented from showing signs of pain, fear, distress and welfare consequences even though they remain conscious.

In the United States, for example, electrical waterbath stunning involves pulsed direct current with low current (25–45 mA/bird), low voltage (10–25 V), and high frequency (approximately 500 Hz) (AVMA, 2016), which might lead to animals being immobilised without reaching unconsciousness.

Clearly, induction of seizures in conscious birds or electro-immobilisation with ineffective stunning current parameters would obviously cause pain and fear, and these birds would remain sensible and able to feel pain during their subsequent slaughter, i.e. cutting of necks and bleeding to death. This practice should therefore be avoided.

In addition, some religious certification bodies in Europe require the use of 45 mA delivered using a 500 Hz pulsed direct current in waterbath stunners (Wotton et al., 2014) because these electrical parameters do not result in cardiac arrest at stunning, ensuring that these birds are still alive. Evidently, such inappropriate electrical stunning parameters will induce electrical immobilisation rather than unconsciousness. It is commonly admitted that high current low frequency is the best combination to achieve unconsciousness in birds but it could lead to meat quality defects (Hindle et al., 2010), representing a conflict between animal welfare and meat quality in waterbath stunning situations. But Ali et al. (2007) argued that high stunning currents (with high frequency) also result in carcass and meat quality defects. It would therefore be difficult, if not impossible, to achieve good welfare as well as acceptable meat quality.

¹⁹ <https://inspection.gc.ca/food/food-specific-requirements-and-guidance/meat-products-and-food-animals/guidelines-for-stunning-techniques/eng/1538160892409/1538160892704>

During deviation on the use of waterbath, birds can be exposed to the same hazards and welfare consequences as for stunning, but the electrical parameters describe above can lead to electro-immobilisation of conscious animals, preventing them from showing signs of pain and fear.

3.2.1.2. Head-only

Process description

Head-only electrical stunning is based on the principle that passage of an electric current of sufficient magnitude through the brain of the bird should induce a generalised epilepsy in the brain. Head-only electrical stunning is applied using two electrodes on either side of the bird's head, such that they span the brain. The birds can be restrained either manually (Figure 8b), in a cone (Lambooi et al., 2014) or by being shackled (Figure 9a,b) prior to stunning. As the birds are individually exposed, a constant current could be delivered to each bird (Berg and Raj, 2015). According to Ohm's law, the amount of current flowing through the brain would be inversely proportional to the total electrical resistance in the pathway. In this regard, electrically resistive components in the pathway include the electrode material itself, cleanliness of the electrodes, amount of feather cover, dryness of the skin, amount of subcutaneous tissue and fat, and density and porosity of the skull bones.

Ideally, head-only electrical stunning should be performed using a constant current source and the minimum current should be applied to ensure unconsciousness. However, most of the head-only electrical stunning equipment used around the world is supplied with a constant voltage, and in some countries, this is limited to 110 V for operators' health and safety reasons. Such a low voltage may not be adequate to deliver the minimum currents necessary to induce immediate loss of consciousness, especially when the electrical resistance in the pathway is too high as, for example, in waterfowl (ducks and geese). The electrical requirements for head-only electrical stunning equipment are, expressed as minimum currents: 240 mA for hens and broiler chickens, and 400 mA for turkeys (Council Regulation (EC) No 1099/2009). The exposure time should be long enough to ensure that birds show proper signs of unconsciousness, usually indicated by tonic seizure activity. No published data are available referring to the minimum currents necessary to achieve effective head-only electrical stunning of other domestic birds (EFSA, 2004).

Beyssen et al. (2004) investigated the efficacy of head-only electrical stunning of ducks with a 50-Hz AC delivering constant currents of 100 (n = 4), 200 (n = 12), 300 (n = 13), 400 (n = 9) or 600 mA (n = 7) for 4 seconds via electrical tongs (spiked electrodes) placed firmly on the ears. The feathers on the head were wetted using saline water to improve the current flow through the skull. The birds were manually bled out within 15 s of the end of the stun by severing the carotid arteries and jugular veins in the neck. The calculated impedance of the wet head was $296 \pm 21 \Omega$. The results showed that the application of 100–400 mA failed to stun some birds, and some others regained consciousness before death occurred from bleeding. After a 600 mA stun, however, all birds were rendered unconscious until death occurred.

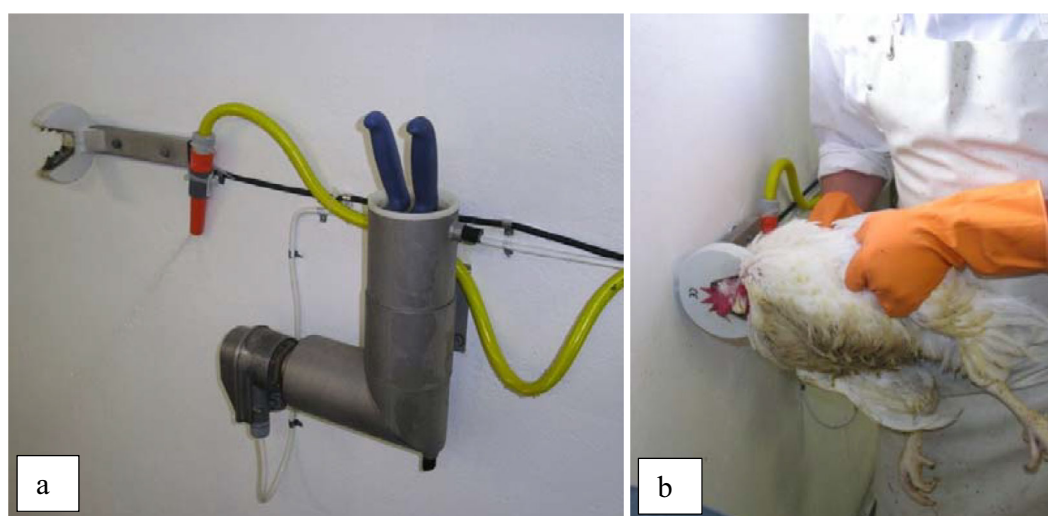


Figure 8: (a) Equipment for head-only stunning in poultry; (b) manual restraint during poultry head-only electrical stunning. Source: kindly provided by Berg C

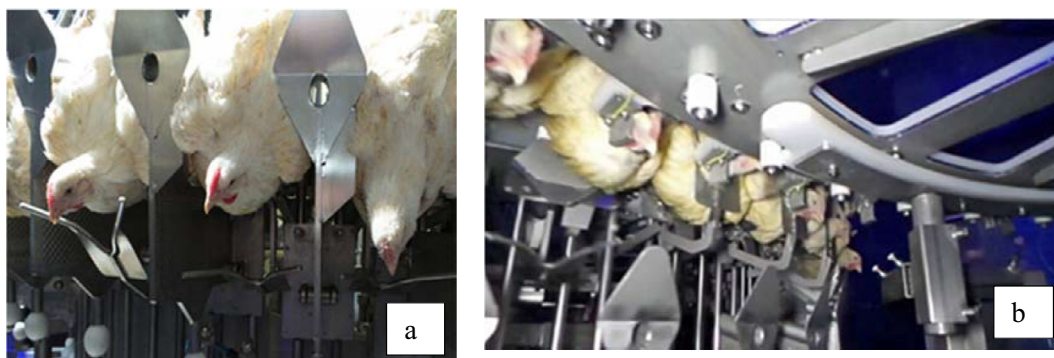


Figure 9: Shackle of conscious birds in head-only electrical stunning: bird position (a) and entering stunning wheel (b). Source: Dutch Vision Solutions

Related hazards and welfare consequences

The hazards identified during this process are: 'manual restraint', 'inversion', 'shackling', 'drops, curves and inclination of shackle line' and 'inappropriate shackling', which are hazards that can cause pain and fear. Other hazards identified during this process are: 'poor electrical contact', 'too short exposure time' and 'inappropriate electrical parameters'. This second group of hazards can cause failure in onset of unconsciousness (consciousness), leading to pain and fear.

The hazards identified during 'head-only electrical stunning', relevant welfare consequences and related ABMs, origin of hazards, and preventive and corrective measures are reported in Table 14.

Assessment of animal welfare

There is limited information available regarding suitable indicators for monitoring stun quality in birds stunned using head-only electrical stunning. Nevertheless, the indicators often applied when looking for signs of consciousness in birds stunned using electrical waterbath stunning can also be applied to head-only stunning. Such indicators are the absence of tonic seizures, presence of breathing and spontaneous blinking. Vocalisation and eye reflexes can also be included, and the presence of wing-flapping is a reliable indicator of consciousness (EFSA AHAW Panel 2013; Grilli et al., 2015; see Section 3.7.2).

3.2.2. Controlled atmosphere stunning methods

Considerations on restraint

CAS includes gas stunning methods and low atmospheric pressure stunning (LAPS); it is used to avoid the pain associated with shackling conscious birds in the case of electrical or mechanical stunning methods. The use of CAS is limited to birds in containers or on conveyors. Several commercially available CAS systems differ in the way birds are placed in the stunning system. Crates, containers or de-stacked drawers can be conveyed through a CAS system. In these processes, no handling of conscious birds is required. Shackling and handling are performed after the birds are stunned with a gas mixture (AVMA, 2016).

General description of gas methods

During exposure to the gas mixture, birds gradually lose consciousness (specific processes are described in Sections 3.2.2.1–3.2.2.3). Birds like chickens, turkeys, ducks, geese, have been reported to be effectively stunned under commercial slaughter conditions by exposure to different gas mixtures (Gerritzen et al., 2006, 2007, 2013; McKeegan et al., 2007a; McKeegan et al., 2007b). Birds are exposed to appropriate gas mixtures for long enough to render them irreversibly unconscious before shackling.

Considering that birds can be gas-stunned in large batches (quantities), the interval between the end of exposure to the gas and neck cutting is likely to be long, particularly for the last birds of the gas-stunned batch to be presented for neck cutting. Therefore, to prevent a return of consciousness either prior to neck cutting or during bleeding, the duration of unconsciousness induced with gas stunning needs to be longer than that required in, e.g. electrical stunning situations.

Appropriate gas concentrations must be monitored continuously at the bird levels inside the chamber. Besides gas concentration and exposure time, other key factors to monitor are the temperature and humidity of the gas mixture.

Related hazards and welfare consequences (and ABMs)

The hazards identified during gas stunning methods are: 'exposure to too high CO₂ concentration', 'too short exposure time' and 'too low concentration of gas'. These hazards can cause consciousness, (respiratory) distress, pain and fear.

The rate of induction, depth and duration of unconsciousness induced with gas mixtures depend on both exposure time and gas concentration (see also Sections 3.6.2.8 and 3.6.2.12). Higher concentrations of CO₂ require shorter exposure times to induce a sufficient level of unconsciousness than lower CO₂ concentrations. Exposure times and gas concentrations are therefore two crucial parameters to control during gas stunning. Exposure of conscious birds to more than 40% CO₂ will cause painful stimulation of the nasal mucosa and aversive reactions. Birds will react with vocalisations, severe headshaking, heavy breathing, escape attempts or severe wing flapping (Gerritzen et al., 2007).

During the induction, gasping (deep breathing with a stretched or arched neck) and headshaking will in fact occur (McKeegan et al., 2006; Abeyesinghe et al., 2007; Gerritzen et al., 2007; Nicolau et al., 2015). Gasping is inherent to carbon dioxide stunning whereas headshaking can be a reaction to different situations. It is perceived as an alarming or alerting response, but it also is associated with a reaction to unpleasant or painful inhalation of gas. After some time, birds will lose balance, frequently being corrected by wing flapping; this should not be interpreted as escape attempts. Loss of posture and thus being unable to maintain body position indicates the moment of loss of consciousness (Gerritzen et al., 2004). After loss of posture, when animals are unconscious, gasping will continue for some period and convulsions (uncontrolled muscular movements) can occur. It has been suggested that presence of consciousness may persist during the occurrence of convulsions and respiratory discomfort occurring at the same time is a welfare issue (Coenen et al., 2009).

The interpretation of visual ABMs during the exposure to gas mixtures depends strongly on the moment that behavioural expressions start. For example, continuous wing flapping that starts directly after exposure can be indicating escape attempts and is seen as an aversive reaction to high CO₂, whereas wing flapping to regain or maintain posture does not necessarily indicate an aversive response to high CO₂. In addition, for headshaking, the interpretation depends on the intensity and level of headshaking. Severe or vigorous headshaking can be interpreted as a sign of painful or irritating inhalation of gas mixtures.

The hazards identified during 'gas stunning', relevant welfare consequences and related ABMs, origin of hazards, preventive and corrective measures are reported in Table 15.

Assessment of animal welfare

At the end of CAS, birds should be checked at key stages for unconsciousness using appropriate tool boxes published by the EFSA AHAW Panel (2013) to ensure that animals will not be submitted to pain, fear or respiratory distress. In most cases, birds will be dead when exiting the CAS system. In these cases, it is important to ensure that all birds are dead before processing them. Death can be confirmed from permanent absence of breathing, absence of corneal or palpebral reflex, dilated pupils and relaxed carcass (EFSA AHAW Panel, 2013).

The process descriptions of four different CAS methods (carbon dioxide in two phases, mixture of carbon dioxide with inert gases, inert gases, LAPS) are reported in the sections below.

3.2.2.1. Carbon dioxide in two phases

Conscious birds are exposed to a gas mixture containing up to a maximum of 40% carbon dioxide followed, when animals lose consciousness, by a higher concentration of carbon dioxide. The first and second phases can be divided into more concentration steps (Gerritzen et al., 2013) if it is ascertained that birds are unconscious before being exposed to carbon dioxide at over 40%. The duration of exposure to each phase varies according to the concentration of carbon dioxide.

3.2.2.2. Mixture of carbon dioxide with inert gases

Conscious birds are exposed to a gas mixture containing up to a maximum of 40% carbon dioxide mixed with inert gases (nitrogen or argon) leading to anoxia (Raj et al., 1992; Raj and Gregory, 1994). The method is considered a simple stunning system if the exposure time is less than 3 min.

3.2.2.3. Inert gases

This is the exposure of conscious birds to an inert gas mixture (such as argon or nitrogen with a maximum of 2% residual oxygen) leading to rapid loss of consciousness and onset of death (Raj et al.,

1991, 1998; Raj and Gregory, 1994). The method is considered a simple stunning system if the total exposure time is less than 3 min.

Animals, including birds, do not have intrapulmonary chemoreceptors to detect inert gases and therefore do not show any aversion during initial exposure to hypoxia/anoxia induced with nitrogen, argon or their mixtures. Webster and Fletcher (2004) reported that, in an avoidance test, hens showed the least number of stops and retreats during approach to argon atmosphere when compared with carbon dioxide, and the behaviour of the birds has been described as very similar to that observed in air. In addition, the highest percentage of the test hens was stunned in the chamber when argon was presented, whereas, most of the hens hesitated to enter the chamber containing carbon dioxide and were therefore stunned in the corridor leading to the chamber. Similar results have been reported for turkeys (Raj, 1996).

3.2.2.4. Low atmospheric pressure stunning

In this method, broilers are placed in containers into the decompression chamber and exposed to gradual decompression with a reduction of available oxygen to less than 5% (Vizzier-Thaxton et al., 2010; Mackie and McKeegan, 2016; Martin et al., 2016a,b,c; Holloway and Pritchard, 2017). This method was found to be acceptable based on the published scientific evidence for broiler chickens only up to 4 kg live weight. During the first phase, the decompression rate shall not be greater than equivalent to a reduction in pressure from standard sea level atmospheric pressure of 760 Torr to 250 Torr for a period of not less than 50 s. During a second phase, a minimum atmospheric pressure of 160 Torr shall be reached within the following 210 s. The pressure–time curve shall be adjusted to ensure that all birds are irreversibly stunned and killed within the cycle time of 280 s (EFSA AHAW Panel, 2017).

Related hazards and welfare consequences

The hazards identified for this process are: 'too fast decompression', 'expansion gases in the body cavity', and 'too short exposure time'. These hazards can cause the following welfare consequences: consciousness, pain and respiratory distress.

The hazards identified during 'LAPS', relevant welfare consequences and related ABMs, origin of hazards, preventive and corrective measures are reported in Table 16.

3.2.3. Mechanical methods (including restraint)

The mechanical methods described in this report are captive bolt, percussive blow to the head, cervical dislocation and decapitation.

Assessment of animal welfare

Effective mechanical stunning leads to destruction of the brain and immediate onset of wing flapping due to the loss of control of the brain over the spinal cord. Since mechanical stunning is applied on individual birds, its efficacy can be assessed immediately after the stun.

Death can be confirmed from several indicators: permanent absence of breathing, absence of corneal or palpebral reflex, dilated pupil, or relaxed carcass (see EFSA AHAW Panel, 2013).

These methods are mainly used as backup or for small-scale slaughtering as in small abattoirs or on-farm slaughter.

3.2.3.1. Captive bolt

Process description

This method requires individual handling of the birds and restraint for correct application. The handling of live birds may cause fear and carries the risk of painful injuries to the birds. Captive bolt is stipulated in Council Regulation (EC) No 1099/2009 as a reversible (simple) stunning method; however, scientific evidence demonstrated that, if the captive bolt is properly applied in poultry, the stunning is irreversible (Raj and O'Callaghan, 2001; Erasmus et al., 2010a,b).

Captive bolts can be either penetrative or non-penetrative and powered by cartridge, compressed air or spring-loaded. An operator shooting with a captive bolt gun must restrain the head by gently holding the beak with one hand and placing the gun on the bird's head with the other hand (European Commission, 2017b, 2018b) (Figure 10). Manual restraint may be applied by one operator holding the individual bird by the legs while the other operator performs the shooting. Captive bolt guns should be placed firmly and perpendicularly on the parietal bones of restrained birds before being fired. Shooting of birds with both types of captive bolts leads to severe damage to skull bones, and the bolt diameter and penetration depth are sufficient to cause damage to the brainstem, leading to irreversible loss of

consciousness. It has been suggested that the appropriate specifications for captive bolt stunning of broilers are a minimum of 6-mm bolt diameter driven at an air pressure of 827 kPa to a penetration depth of 10 mm (Raj and O'Callaghan, 2001).



Figure 10: Restraint and application of captive bolt stunning. Source: European Commission, 2018b

When captive bolt stunning is applied to birds, it is important the birds are restrained in a bleeding cone to contain wing flapping.

The power of the cartridge, compressed air line pressure or spring should be appropriate for the species and size of birds. Damp cartridges will fail to stun the birds effectively. Operator fatigue and overheating of the gun due to repeated firing can lead to poor welfare. There should be sufficient bolt guns such that they are allowed to cool between operations, and they should be cleaned and maintained according to manufacturer's instructions.

The bolt diameter and the strength and penetration depth of the gun are important parameters to ensure efficacy of the stun. Martin et al. (2019), evaluated a captive bolt device with a 6-mm diameter bolt, a penetration depth of 2.5–3.5 mm and delivering an impact energy of 11.87 J, and reported only a 75% success rate in causing death in chickens. If the bolt is too narrow (less than 6 mm), or the velocity is too low, there will not be enough energy transfer to the head to induce effective stunning (Karger, 1995; Raj and O'Callaghan, 2001; EFSA, 2004).

There are spring-operated captive bolt guns on the market specifically designed for stunning poultry such as ducks, geese and turkeys up to 16 kg (<https://www.msschippers.com/dick-captive-bolt-gun-for-small-animals-3409913.html>).

In a spring-loaded captive bolt, when the bolt remains extended, it can be used to swiftly destroy the brain right after firing provided the bolt had first rendered the bird unconscious.

Related hazards and welfare consequences

The hazards identified during this process are: 'manual restraint' and 'inversion', which can cause pain and fear; 'incorrect shooting position' and 'incorrect captive bolt parameters', which can cause consciousness, leading to pain and fear.

The hazards identified during 'captive bolt stunning', relevant welfare consequences and related ABMs, origin of hazards, preventive and corrective measures are reported in Table 17.

3.2.3.2. Percussive blow to the head

Process description

This method is performed by holding a bird by its legs, placing its head on a hard surface and delivering a blow to the back of the head with a hard object (European Commission, 2018a). The

percussive blow with a metal pipe, bat or solid wooden stick is delivered to the head with sufficient force and accuracy to lead to brain concussion. This method has been reported by Erasmus et al. (2010a,b) to be effective when performed by a trained operator. It can also be performed by holding the bird with both hands around its body and swinging the bird's head towards a hard, stable object such as the rim of a table.

EEG data showed that the blunt trauma induced by a single, sufficiently strong hit placed in the frontoparietal region of the head of broilers, broiler breeders and turkeys weighing up to 16 kg led to a reduction or loss of the auditory evoked potentials (AEPs) in all groups of birds, suggestive of unconsciousness (Cors et al., 2015).

However, it is doubtful whether a percussive blow delivered to a bird held upside down by its legs would be consistently effective without first resting its head on a hard surface.

Considering that the application of this method is entirely manual and prone to error, percussive blow might be used only when no other stunning method is available and, according to Council Regulation (EC) No 1099/2009, if it is used, it can be performed only on 70 birds/person per day to avoid errors due to operator fatigue.

Related hazards and welfare consequences

The hazards identified during this process are: 'manual restraint' and 'inversion', which can cause pain and fear, and 'incorrect application', which can cause consciousness, leading to pain and fear.

The hazards identified during stunning with 'percussive blow', relevant welfare consequences and related ABMs, origin of hazards, preventive and corrective measures are reported in Table 18.

3.2.3.3. Cervical dislocation

Process description

Cervical dislocation can be performed manually or mechanically; in the EU, Council Regulation (EC) No 1099/2009 stipulates that this method can be performed only on 70 birds/person per day to avoid errors due to operator fatigue; in addition, it states that cervical dislocation can be performed manually on birds weighing up to 3 kg, and that it should be performed mechanically on birds weighing between 3 and 5 kg. No cervical dislocation is allowed on birds weighing more than 5 kg.

- Manual neck or cervical dislocation (MCD), by stretching and twisting, as a best practice should always result in the separation of the spinal cord from the brain (AVMA, 2013; European Commission, 2018a). It is performed in one continuous movement (HSA, 2004) by pulling both hands quickly and firmly in opposite directions in a slightly twisting manner, and twisting of the head back sharply (see Figure 11). It is frequently used as a backup method in slaughter plants when the primary stunning method fails. However, it has been demonstrated that MCD, even with separation of the spinal cord, failed to produce immediate loss of consciousness or signs of brain concussion in some of the birds tested in the study, and it was concluded that these birds may die due to asphyxiation (Gregory and Wotton, 1990).
- Mechanical cervical dislocation is performed by using devices that dislocate by stretching or crushing. The equipment used for cervical dislocation by stretching typically consists of a restraining cone mounted on a tripod with a neck clamp fixed to a pivot below the cone. The bird is restrained head down in the cone and the neck placed into the clamp so that it rests just behind the head. It is essential that the bird is held firmly in the cone before applying the neck clamp. The concerns presented under the manual cervical dislocation by stretching would also apply to the mechanical application. Mechanical cervical dislocation by crushing at the first cervical vertebra with a pair of pliers such as 'Semark pliers' or the 'Burdizzo' has been used for cervical dislocation. Neck crushing does not sever the common carotid arteries and does not reduce neck diameter. If the spinal cord is severed in this way without stopping blood supply to the brain, it does not cause cerebral ischemia and hence loss of consciousness (Gregory and Wotton, 1990; Martin et al., 2017). Similar conclusions were reached in studies on different species of poultry (Erasmus et al., 2010a,b,c; Sparrey et al., 2014; Martin et al., 2016d, 2018).

It has to be noted that, to the experts' knowledge, there is no sound scientific data available in the literature to suggest cervical dislocation can be performed humanely in other species of domestic birds than chickens.



Figure 11: Illustration of manual cervical dislocation by pulling (1) and twisting (2) of the head dorsally in one continuous motion. Source: European Commission, 2018a

Related hazards and welfare consequences

The hazards identified during this process are: 'manual restraint', and 'inversion', which can cause pain and fear only in cases of failure of the stunning method applied and recovery of consciousness; 'incorrect application', may also occur and be the cause of consciousness leading to pain and fear.

Pulling down by the neck on a bird that is too small for the device will simply pull it further into the cone until it is wedged, fail to dislocate its neck, and cause it to be injured. Extension of the wings back up the cone may also prevent the device from working, so when the bird is placed in the cone, it is essential the wings are folded close to the body and remain within the cone (Sparrey et al., 2014).

Because cervical dislocation does not always lead to immediate onset of unconsciousness in all the birds (EFSA, 2004), animal welfare concerns mean it should be only used as a backup at the slaughterhouse and not as a routine method.

The hazards identified during 'cervical dislocation', relevant welfare consequences and related ABMs, origin of hazards, preventive and corrective measures are reported in Table 19.

3.2.3.4. Decapitation

Process description

Decapitation is not on the list of stunning methods provided in Council Regulation (EC) No 1099/2009. In the USA, it has been reported as not commonly employed in the commercial slaughter of food animals but is often used for on-the-farm slaughter (AVMA, 2016).

This practice involves separation of the head from the body by severing the neck close to the head (Close et al., 1996) causing death through anoxia of the central nervous system and blood loss. It is performed in one cut using a purpose-built mechanical device with a sharp blade, i.e. a guillotine. The blade should be accurately placed high on the neck, ideally at the level of the first vertebra, and be able to sever the entire head without needing more than one blow. Birds must be restrained to prevent them from moving away from the blade.

Decapitation results in severe wing flapping, which can be hazardous, especially when dealing with turkeys (EFSA, 2004). Restraint in a bleeding cone will therefore not only facilitate accurate aim but will also minimise tissue trauma from post-mortem convulsions.

Research has shown that there is brain activity (visual evoked responses) for up to 30 s after decapitation in chickens (laying hens) (Gregory and Wotton, 1986); loss of consciousness may therefore not be immediate. During this time, animals may feel pain due to afferent stimuli from the

trigeminal nerve (EFSA, 2004). No additional data are available on whether decapitation in poultry leads to immediate loss of consciousness (due to hypovolemia, for example).

Considering these elements, decapitation is not recommended to be used for stunning animals.

3.3. Description of Phase 3: bleeding and relevant welfare consequences

General consideration

This phase includes bleeding of the birds following stunning and bleeding during slaughter of poultry without stunning. These processes are described in Sections 3.3.1 and 3.3.2. The outcome table related to each process is reported in Section 3.10.3 (Tables 20 and 21).

In this phase, animals should first be checked for unconsciousness (at the end of stunning) through the assessment of indicators of unconsciousness (see Section 3.7.2).

In the case of bleeding following stunning, both the carotid arteries should be severed swiftly to prevent recovery of consciousness.

Council Regulation (EC) No 1099/2009 considers the main stunning methods, i.e. head-only and waterbath electrical stunning, exposure to controlled atmospheres, and captive bolt, to be reversible stunning methods (simple stunning). In this sense, these methods induce momentary loss of consciousness and therefore the onus of preventing recovery of consciousness following stunning relies solely on prompt and accurate neck cutting, i.e. severing both carotid arteries supplying oxygenated blood to the brain. It is expected that unconsciousness induced by stunning should last longer than the time interval between the end of stunning/neck cutting and the induction of death due to blood loss following neck cutting (Figure 12). The Regulation stipulates that both carotid arteries should be severed following stunning, and birds should be confirmed to be dead before carcass processing (i.e. entering the scalding tank).

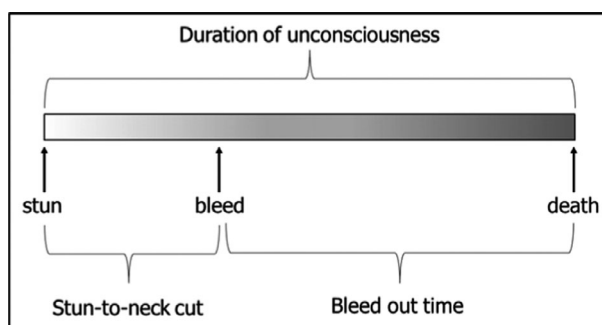


Figure 12: An illustration of the duration of stun-to-neck-cutting and bleeding. Unconsciousness after stunning should persist during bleeding, until the animal is dead (from EFSA, 2004)

In broilers, the time to onset of an isoelectric EEG indicative of brain death following effective waterbath electrical stunning and severance of two carotid arteries and two jugular veins has been reported to be about 22 s (Raj, 2006).

Assessment of animal welfare

Loss of consciousness and death should be assessed after bleeding to prevent birds entering the scalding tank while still alive. Live birds can be recognised from the presence of breathing or of the corneal and palpebral reflexes, pupils that are not fully dilated, continued bleeding, or the presence of muscle tone and body movements (EFSA AHAW Panel, 2013).

3.3.1. Bleeding following stunning

Process description

Reversible (simple) stunning methods inducing momentary loss of consciousness and therefore rely on prompt and accurate bleeding to prevent recovery of consciousness. In this regard, vessels supplying oxygenated blood to the brain, i.e. both carotid arteries, must be severed as soon as possible after stunning (neck-cutting). For poultry at the slaughterhouse it can be performed by single or twin-bladed neck-cutting machine or manually with a sharp knife.

There are no specific studies on turkeys, but according to the EFSA AHAW Panel (2013), turkeys are more resilient to brain ischaemia and, therefore, the times to onset of unconsciousness and death are expected to be significantly longer than for chickens.

Related hazards and welfare consequences

If animals are conscious during bleeding due to ineffective stunning or prolonged stun-to-neck cutting interval after reversible stunning applications, the risk of impaired animal welfare increases. First, the incision made in the neck involves substantial tissue damage in areas well supplied with nociceptors (Kavaliers, 1989). The activation of the protective nociceptive system induces the animal to experience pain. Secondly, death due to sticking is not immediate, and there is a period of time during which the animal is still conscious and can feel negative welfare consequences such as fear, pain and distress (EFSA AHAW Panel, 2013).

The hazards identified during this process are: 'prolonged stun-to-neck-cut interval', 'incomplete sectioning of carotids' and 'entering the scalding tank alive', which are hazards that can cause consciousness leading to pain, fear and distress. The birds that are ineffectively stunned or those recovering consciousness can be exposed to pain also due to 'neck cutting', and eventually 'repeated cuts' and 'stimulation of the wound'. These birds will also experience fear and distress when 'bled to death'. Properly stunned animals do not experience the above reported negative welfare consequences during bleeding.

The hazards identified during 'bleeding following stunning', relevant welfare consequences and related ABMs, origin of hazards, preventive and corrective measures are reported in Table 20.

3.3.2. Bleeding during slaughter without stunning (including restraint)

Process description

Slaughter without stunning results in gradual loss of consciousness and onset of death through blood loss. This killing method may be performed on individual birds restrained manually or on birds that have been shackled on a moving metal shackle line. Because poultry are conscious during slaughter, impairment of the of the animals' welfare will occur in three aspects: (i) restraint, (ii) incision of the neck and (iii) gradual onset of unconsciousness and death.

Related hazards and welfare consequences

- During restraint

The hazards identified during the restraint of this process are: 'manual restraint', 'inversion', 'shackling', 'drops, curves and inclination of the shackle line' and 'inappropriate shackling'. These hazards can cause pain and fear as welfare consequences. Catching and robust restraint of conscious animals for neck cutting causes negative welfare consequences such as pain and fear, especially when birds are hung upside down by the legs in shackles. Other less-stressful restraining methods include the placement of the bird in a cone, manually by a person holding both of the legs, or in lateral recumbency (von Holleben et al., 2010). In all cases, as a best practice, restraint must be as short as possible. Birds must be restrained only when slaughter can be performed without delay. The restraining device must suit the size, species and type of birds slaughtered and must not cause injuries. The restraint must be such that it provides good access to the neck for effective neck cutting and bleeding out.

- During incision

The hazards identified during the incision are: 'neck cutting', 'incomplete sectioning of carotids', 'repeated cuts', 'stimulation of wound', bleeding to death', and 'entering the scalding tank alive'. These hazards can cause consciousness, pain, fear and distress.

The incision made in the throat to sever blood vessels involves substantial tissue damage in areas well supplied with a high density of nociceptors. The activation of the protective nociceptive system induces the animal to experience severe pain. There are factors that can increase pain perception, such as performing multiple cuts (more nociceptors are affected), changes of direction of the cut, blunt knife (extension of the lesion), insufficient length of the knife, wound manipulation or presentation of the neck in a position disturbing a good cut or the flow of blood (e.g. increased flexibility of the skin due to insufficient tension) (von Holleben et al., 2010).

Onset of unconsciousness and death due to bleeding are not immediate. Birds are gradually rendered unconscious as brain perfusion becomes insufficient to sustain normal function. Broiler chickens lose consciousness on average between 12 and 15 s after the cut (Barnett et al., 2007). During this period,

the bird is still conscious and can feel pain, fear and distress. Any circumstance that delays the loss of consciousness in the bird will prolong the pain perception (von Holleben et al., 2010). Therefore, while bleeding during slaughter without stunning, the wound site must remain open to enable profuse bleeding and further stimulation of the wound (such as physical contact or scraping) during the conscious period must be prevented. As many factors may lead to poor welfare, continuous and systematic monitoring is required for any sign of life before scalding of all birds slaughtered and bled without stunning.

According to Barnett et al. (2007), broiler chickens lose about 40% of their total blood volume within 30 s after neck cutting. It is suggested that, on average, non-stunned chickens lost consciousness between 12 and 15 s after the cut due to brain ischemia through blood loss, although the same author (Barnett et al., 2007) described a case where more than 25 s elapsed before the onset of unconsciousness. This time might be longer in cases of inappropriate neck cutting (e.g. a cut that severs only the veins or one artery). In contrast, Cranley (2016) reported that aversive/anger-type behaviour was found in all broilers subjected to slaughter without stunning from 10 to over 40 s after incision of both carotids and both jugulars, before death at 60 s. In some cases, the prolonged fear/anger-type behaviour more than 90 s after incision indicated a risk of consciousness and sensibility, and failure to sever both the carotid arteries may be linked to prolonged or resurgent aversive or anger-type behaviours.

The hazards identified in the case of 'bleeding during slaughter without stunning', relevant welfare consequences and related ABMs, origin of hazards, preventive and corrective measures are reported in Table 21.

3.4. Emergency killing

Council Regulation (EC) No 1099/2009 defines emergency killing as the killing of animals that are injured or have a disease associated with severe pain or suffering and where there is no other practical possibility to alleviate this pain or suffering.

In birds with severe pain and suffering, emergency killing should be carried out at arrival, during lairage or at the time of shackling. Conditions that will induce severe pain and suffering are, e.g. fractures, bone dislocations and open wounds. The responsible person should therefore ensure that the slaughter plant has procedures, facilities and equipment for killing these animals outside of the normal slaughter line.

3.5. Unacceptable methods, procedures or practices on welfare grounds

The Panel agrees with the principles of the OIE Terrestrial code (Chapter 7.5.10 of OIE, 2019) in that the following methods, procedures or practices should be considered unacceptable on welfare grounds:

- 1) *In any species: the restraining methods which work through electro-immobilisation or immobilisation by injury such as breaking legs, leg tendon cutting, and severing the spinal cord (e.g. using a puntilla or dagger) that cause severe pain and stress in animals.*
- 2) *In any species: the use of the electrical stunning method with a single application leg-to-leg.*
- 3) *In any species: the slaughter method of brain stem severance by piercing through the eye socket or skull bone without prior stunning.*

This therefore applies in conscious poultry for example in the case of electro-immobilisation for neck-cutting or preventing wing flapping during bleeding, or the method of brain piercing through the skull without prior stunning.

3.6. Response to ToR-1: hazard identification, origin and specific preventive and corrective measures

According to the EFSA AHAW Panel (2012a), a hazard is any aspect of the environment of the animal in relation to housing and management, animal genetic selection, transport and slaughter that may have the potential to cause poor welfare.

In this opinion, hazards have been identified through the activities described in Section 2.2 and analysed for each phase and process under consideration. The hazards listed in the following sections are related to conscious animals.

According to the mandate, the possible origin of the hazards, in terms of equipment or staff, should also be identified. When discussing these categories, it was agreed that the 'origin' can be further explained by detailing what actions from the staff or features of the equipment and facilities can cause the hazard.

Therefore, for each 'origin category' (facilities/equipment and staff), relevant explanations (so called 'origin specifications') have been specified.

The mandate also requests preventive and corrective measures regarding the different hazards identified. Quite often, mainly in stunning and bleeding phases, corrective measures do not exist (e.g. in the case of too long food deprivation). In this case, measures to mitigate the welfare consequences can apply; however, most often, the main mitigation measure is to slaughter the animal as soon as possible (see also Section 3.7.1). In cases where the stunning method fails, a backup method should be applied to mitigate severe welfare consequences such as pain and fear. When preventive and corrective measures can be identified, if they are specific for a particular hazard, they will be described in this section together with the relevant hazard. If the preventive and corrective measures available can apply to several hazards (general measures), they will be described under Section 3.8 (response to ToR-3). When no further explanation is needed, reference to the outcome tables will be made.

The hazards that have been identified in the context of poultry slaughtering have been grouped into three main categories by slaughtering phase: (a) during the pre-stunning phase, (b) during the stunning phase, and (c) during the bleeding phase.

The identified hazards with relevant origin categories and origin specifications are listed in the outcome tables (Tables 9–21, Section 3.10: first column, hazards; third column, origin category; fourth column, origin specification). In addition, considering that each hazard may lead to one or more negative consequences on the welfare of the birds, the outcome tables also report the welfare consequences with which each hazard is associated (second column of the outcome tables mentioned above).

The following sections report the full list of the 35 hazards identified along with their definitions, indications of which process they apply to, and relevant preventive and corrective measures.

3.6.1. List of hazards during Phase 1 – pre-stunning

3.6.1.1. Too high effective temperature

Definition: The effective temperature perceived by an animal is a combination of the temperature, the humidity and the ventilation or speed of wind. In hot and humid environmental conditions, poor ventilation will exacerbate the perceived temperature. When the effective temperature is too high (above their thermoneutral zone (15–25°C and 60–65% humidity; DEFRA, 2005), the thermoregulatory capacities of the birds for homeothermy are exceeded and they show difficulty achieving a balance between body heat production and body heat loss that leads to heat stress (for detail about welfare consequences, see Section 3.7.1).

Processes of slaughtering to which this hazard applies: Arrival and lairage.

Hazard's preventive and corrective measures: Reduction of the stocking density helps to control the build-up of heat and humidity (Nijdam et al., 2004; Chauvin et al., 2011). This was illustrated by Warriss et al. (1992) where the mortality was reduced from 0.22% to 0.16% from March to August in one UK plant, despite the increasing ambient temperature, by reducing stocking density progressively from, on average, 17.3 to 15.8 birds per transport crate.

Some preventive measures have to be put in place at the time of transportation, e.g. avoiding the hottest hours of the day for transportation of animals will allow them to avoid experiencing extremes in climatic conditions, which are especially problematic when trucks are not equipped with ventilation systems (Warriss et al., 2007). To prevent and correct too high effective temperatures experienced by the birds in hot climatic conditions, it is suggested to remove curtains from the truck and provide adequate ventilation. These measures would allow the birds to stay in their thermoneutral zone.

At arrival, when there is a too high effective temperature, as a best practice, birds should be protected from the sun or unloaded immediately from the truck.

At arrival and lairage, if effective temperature is still above thermoneutral zone (it can be checked by measuring temperature and relevant AMBs (for details, see Section 3.7.2)), ventilation should be provided and, in certain cases, misting and nebulisation can be applied to the birds to cool them down (Jiang et al., 2015).

At lairage in hot climatic conditions, in addition to ventilation, a good circulation of air at bird level can be ensured by also increasing the space between the stacks of the containers. Vieira et al. (2010) showed that, in climatized holding areas, increased lairage time reduced rectal temperature of broilers, improving their welfare condition. These last authors as well as Bianchi et al. (2005) and Grilli et al. (2015) found that lairage duration did not affect DoA percentages if the environmental conditions were controlled in the holding area. Grilli et al. (2015) stated that lairage facilities should be designed and constructed so that the welfare of animals is constantly ensured.

These measures (ventilation, protection from the sun, nebulisation) can be used separately or in combination, depending on how critical the situation is. They can act as preventive measures, but if not applied first, can act as corrective measures for the hazard and to mitigate the welfare consequence (heat stress, see Section 3.7.1.1).

3.6.1.2. Too low effective temperature

Definition: The effective temperature perceived by an animal is a combination of the temperature, the humidity and the ventilation or wind speed. In cold and humid environmental conditions with high wind speed, the perceived temperature will decrease rapidly. When the effective temperature is too low, the thermoregulatory capacity of the birds for homeothermy is exceeded. Birds can die from hypothermia if the conditions are too cold or the birds are wet and cold (Caffrey et al., 2017).

Processes of slaughtering to which it applies: Arrival and lairage.

Hazard's preventive and corrective measures: Some preventive measures can be taken at the time of transportation, e.g. avoiding the coldest hours of the day for transportation of animals will allow them to avoid extreme climatic conditions, which are especially problematic when trucks are not equipped with curtains (European Commission, 2017a). To avoid too low effective temperatures experienced by birds under very cold climatic conditions, curtains must be installed on the truck to allow the birds to stay in their thermoneutral zone. In Canada, Caffrey et al. (2017) showed that preventive measures such as reduced journey duration and increased stocking densities in containers can mitigate some of the mortality risk during extreme cold conditions experienced during some parts of the year. The same authors showed that during seasons when the external temperature was cold, e.g. $< 0^{\circ}\text{C}$, closing the ventilation openings in the front and top of the trailer and providing curtains reduced the risk of DoA, especially in loads containing wet and cold birds. However, the WG experts felt that insufficient space allowance could have comparable welfare consequences (see Section 3.6.1.3).

At arrival and lairage, if effective temperature is still below the thermoneutral zone (this can be checked by measuring temperature and AMBs (for details, see Section 3.7.2), then adequate shelter should be provided to allow birds protection from the wind.

At lairage in cold weather, it is advisable to reduce the gap between the rows of containers to limit draughts without preventing the movement of employees between crates. It is also advisable to ensure that the doors of the waiting area are properly closed (Marie Bourin, Institut Technique de l'Aviculture (ITAVI), Paris, France, Bourin, personal communication, 2019). A closed shelter with heating should be provided at lairage to prevent or correct the hazard leading to cold stress due to birds getting outside their thermoneutral zone.

These measures (protection from wind, unloading ASAP and heating) can be used separately or in combination, depending on how critical the situation is. They can act as preventive or corrective measures for the hazard and to mitigate the welfare consequence (cold stress, see Section 3.7.1.1).

3.6.1.3. Insufficient space allowance

Definition: The space allowance is the space that an animal can have once it has been placed in the container. In the case of poultry, the space allowance corresponds to what is perceived by the bird, and the more it is reduced, the fewer possibilities the animals have to sit or lie together or change position or stretch their wings. This space will not change until the birds are removed from the container to be shackled or until the containers are automatically unloaded onto a conveyor belt. The space allowance is directly linked to the stocking density in containers, which is usually expressed in animals or kg/m^2 .

A study by Jacobs et al. (2016) undertaken in six slaughter plants found stocking densities from 52 to $83 \text{ kg}/\text{m}^2$ in broiler chicken. These densities are below the maximum authorised by the European legislation (Council Regulation (EC) No 1/2005²⁰). The space allowance is fixed when crating the animals at the farm. High crating densities during transport were reported to be a stressor of the highest importance for broilers and to impact DoA percentage (Chauvin et al., 2011). Nijdam et al. (2004) reported that factors associated with percentage of bruising were season, time of transport, and ambient temperature. Factors associated with DoA percentage were ambient temperature, time of transport, catching company, breed, flock size, mean body weight, mean compartment stocking density, transport time, lairage time, and the interaction term transport time \times ambient temperature.

²⁰ Council Regulation (EC) No 1/2005 of 22 December 2004 on the protection of animals during transport and related operations and amending Directives 64/432/EEC and 93/119/EC and Regulation (EC) No 1255/97. OJ L 3, 5.1.2005, p. 1–44.

Processes of slaughtering to which it applies: Arrival and lairage.

Hazard's preventive and corrective measures: According to DEFRA guidelines (DEFRA, 2005), stocking densities, which are directly linked to the space allowance, should be adjusted according to:

- the temperature/humidity combination;
- module or crate (containers) design;
- trailer design, whether curtain-sided or open-sided – if the performance of a trailer in hot weather is not known, under-stock until experience is gained;
- distance and speed of the journey – if the journey is short and slow, stocking rates should be reduced compared with a longer and faster journey;
- lairage facilities – the lairage ventilation must be equivalent or superior to the vehicle in motion.

Regarding these elements, the only preventive measure for insufficient space allowance is to adjust the number of birds to the size of the containers during catching and crating on the farm. No measures to correct this hazard have been identified, but only to mitigate the welfare consequences of this hazard, but none to correct it (see Section 3.7.1.1).

3.6.1.4. Food deprivation too long

Definition: Food deprivation occurs when birds have no access to food for some hours, leading to hunger, and, in the case of prolonged negative energy balance, difficulties coping with other hazards such as, low temperature, loss of weight, etc. Food deprivation time is the time between the feeders' removal on-farm and the catching of animals plus the time of transportation and waiting before unloading on arrival. It will be extended further during lairage. Normally, poultry are not fed and watered in the container when transport time is less than 12 h (see Council Regulation (EC) No 1/2005). However, if one or more of the above-mentioned periods of time is too long, it leads to too food deprivation.

Food withdrawal before catching at farm level is practiced to allow time for the digestive system to empty before processing, leaving less ingesta and faeces for potential carcass contamination. A secondary advantage is to reduce the risk of defecation onto other birds during loading and while crated (Caffrey et al., 2017).

The same authors showed that increasing the period of feed withdrawal beyond 8–9 h was detrimental as it increased mortality. This was presumably due to the development of a negative energy balance and a decreased ability to cope with cold temperatures (the study was carried out in Canada). When animals are not fasted, they have to mobilise their body energy reserves; if this persists, it can become exhausting and thereby the risk of hypothermia and death increase.

Processes of slaughtering to which it applies: Mainly arrival and lairage; however, birds will be submitted to this hazard until they become unconscious.

Hazard's preventive and corrective measures: To prevent this hazard, the food withdrawal should be planned taking into account transport and lairage times. It is recommended that the time between on-farm withdrawal and end of lairage does not exceed 12 h. This can be achieved by careful planning of these processes (including the transport time), and by scheduling and prioritising the slaughter of the animals. The only identified corrective measure is providing food and water to the animals.

3.6.1.5. Water deprivation too long

Definition: Birds have no access to water for some hours, leading to thirst and, with prolonged dehydration, difficulties in coping with high temperatures etc. Water deprivation time is the result of the time between the drinkers' removal on-farm and the catching of animals plus the transportation time and waiting time before unloading on arrival. It will be extended further during lairage. When one or more of these times is too long, it leads to too long water deprivation.

The need for water of poultry goes from 0.08 L/day for pigeons to 0.8 L/day for turkey or duck breeders. This can be multiplied by three when temperatures are high (Guerin et al., 2016). Birds should have access to water until they are caught and placed in containers. There can be a cumulative effect of deprivation of water with high temperature and high stocking densities.

Processes of slaughtering to which it applies: Mainly arrival and lairage; however, birds will be submitted to this hazard until they become unconscious.

Hazard's preventive and corrective measures: To prevent this hazard, birds need to have access to water until catching. It is recommended that the time between on-farm withdrawal of water and end of lairage does not exceed 12 h. This can be achieved by careful planning of these processes

(including the transport time), and by scheduling and prioritising the slaughter of the animals. The only identified corrective measure is providing water to the birds.

3.6.1.6. Rough handling of containers

Definition: It consists in moving mechanically or manually the containers inappropriately, in a way that cause pain and fear to the birds and resulting in tilting, dropping or shaking.

Process of slaughtering to which it applies: Unloading from the trucks. However, this hazard can occur at any time the containers are moved, e.g. also when moving from lairage to the shackling or stunning point.

Hazard's preventive and corrective measures: Unloading should be performed smoothly and in a horizontal position to prevent tilting of containers that causes birds to pile up or bunch (Grilli et al., 2015). This can be achieved by a good training of the staff about how to handle the containers and how to properly use the forklift or manual trolley for it. The good maintenance of the facility and the equipment will allow to have a forklift functioning softly on an even floor that will lead to proper handling.

3.6.1.7. Jamming or crushing of heads, wings and legs in containers

Definition: It may happen that, during manual or mechanical manipulation of containers, birds put their heads, wings, legs or toes through the grid of the container, and the protruding parts may get stuck between two containers. Injuries may also occur when there are sharp projections inside the containers due to broken plastic or metal surrounds (AVMA, 2016; OIE, 2019).

Process of slaughtering to which it applies: Unloading.

Hazard's preventive and corrective measures: Staff should routinely inspect the containers and remove broken ones that should not be used. If (a part of) a bird has been crushed or jammed, there is no way to correct it; however, pain and fear generated by the hazard can be mitigated (e.g. by stunning the animal as soon as possible; see also Section 3.7.1.1).

3.6.1.8. Unexpected loud noise

Definition: A noise that by its level suddenly induces fear to the animal.

A slaughterhouse is an environment with loud noises originating mainly from machines, the manipulation or movement of containers, and sometimes from personnel shouting. Birds can be submitted to noise in all the processes of slaughtering, but it is of main impact concern during the pre-stunning phase and, in particular, during lairage, because this is where the birds remain for longer periods. During the stunning and bleeding phases, birds are expected to be unconscious and therefore not affected by unexpected loud noises. However, if birds are conscious during these phases, they will experience additional major hazards (e.g. entering the scalding tank alive) that will also lead to pain and fear. There are no available data on noise level that relates to welfare consequences.

Process of slaughtering to which it applies: Lairage.

Hazard's preventive and corrective measures: It is important to limit unexpected loud noises because they leads to fear and decrease coping capacities. The preventive measures will consist in staff education and training (i) to make them aware that noise at the birds' level should be avoided and (ii) to make them avoid shouting and making noise with the equipment and facilities, and identify and eliminate the sources of noise. Regarding facilities and equipment, machines should be setup correctly to avoid excessive noise and facilities should be noise proofed.

3.6.1.9. Rough handling of birds during removal from the containers

Definition: Manual removal of birds from containers in an inappropriate way that causes pain and fear, e.g. by grasping the bird by the neck or by one leg or wing.

Two situations may exist:

- The containers have a narrow door and injuries to the wings might occur if birds are removed inappropriately from the crate.
- The containers are completely open – the birds do not have to go through a door – but operators remove them inappropriately.

Rough handling can cause pain and fear due to injuries. These would appear as main carcass defects and can be seen as post-mortem lesions, such as skin lesions, wing fractures, and bruising on wings and breasts (Jacobs et al., 2017).

Kittelsen et al. (2015) investigated the effects of preslaughter handling procedures on the frequency of wing fractures. Wings were examined for fractures in 11,609 broilers from 12 different flocks slaughtered in two abattoirs, one using biphasic CO₂ stunning, and one using electric water-bath stunning. The same broilers were examined (i) in lairage, representing fractures attributed to catching and transportation; (ii) after evacuation of the transport containers and shackling (for electrical waterbath stunning only); and (iii) post-stunning. The mean frequencies of wing fractures were: 0.8% in the lairage; 2.9% after shackling prior to stunning (electrical water-bath stunning only); and 2.35% after stunning. Regardless of stunning method, significantly more fractures occurred during preslaughter handling at the abattoirs than during catching/transportation (Kittelsen et al., 2015). The bruises cannot be seen on the live animals but become visible after plucking the carcass (feather removal during the slaughtering process).

Process of slaughtering to which it applies: Handling and removing of birds from crates or containers.

Hazard's preventive and corrective measures: To prevent this hazard, it is recommended to remove birds from containers using two hands (Figure 13a), and to remove only one bird from the containers at a time. As best practice, birds should not be carried by their wings or neck, swung, thrown or dropped, and the legs should not be squeezed (see Figure 13b and c). However, some transport containers for turkeys have crates that are fixed on the back of trucks that are driven into the shackling area where operators stand on either side of the truck to remove and shackle the birds. In this situation, birds are moved beyond the reach of operators and are usually pushed using long handled brooms/brushes or pulled roughly.

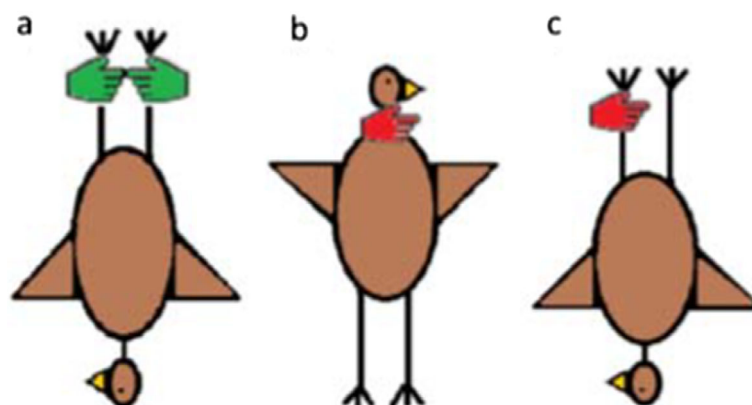


Figure 13: Handling and removal of birds from crates or containers: (a) good handling practice: the operator takes the bird by both legs, using two hands; (b) and (c) inappropriate handling practices: the operator takes the bird by the head or neck or by one leg (source: Federation of French Poultry Industries (FIA))

Careful handling has been reported as a crucial element in reducing mortality prior to slaughter (OIE, 2019). Training of all staff involved in the catching and handling of poultry is the only way to raise awareness of the importance of humane handling. Grandin (1994) showed that the most important influence on how animals are treated is management attitude. Furthermore, the quality of employees and their proper supervision largely determines how many birds are injured (Kettlewell and Turner, 1985). If catchers are careful, conscientious and properly supervised, catching/handling can result in low levels of injuries (Ekstrand et al., 1998).

Containers (crates) used for movement of birds should be placed as close as possible to the shackling area for unloading to minimise operator fatigue and the distance live birds are carried. Furthermore, staff rotation is important to reduce workers' fatigue, which can lead to poor bird handling practices.

In addition, correct choice of container system can help prevent this hazard. In fact, the traditional chicken crates have a narrow opening at the top through which birds are put in or taken out, sometimes more than one at a time (Tinker et al., 2004). In contrast, modular transport systems have a large opening for loading and removing birds and are therefore better for bird welfare by reducing or preventing rough handling.

Therefore, staff training and rotation, use of appropriate wide-opening containers and correct setting up of equipment are the most effective preventive measures. Another way is to slow down the

line speed, as described earlier in this opinion, which can be an effective tool with for dealing with several hazards.

3.6.1.10. Tipping or dumping on conveyors

Definition: When the containers are mechanically emptied by tipping, animals fall on to conveyors. Dumping, piling up and shock might happen, especially for the last birds to be removed, which is often by mechanical shaking of the containers.

Process of slaughtering to which it applies: Handling and removing of birds from crates or containers.

Hazard's preventive and corrective measures: As animals are tipped onto a conveyor belt, the design, position and speed of the equipment should be adapted to the throughput rate of the containers to prevent birds dumping and piling up on the belt. To handle this correctly, staff needs to be educated and trained; staff rotation can also be a tool for avoiding staff fatigue and decreased attention.

3.6.1.11. Bunching on the conveyor belts

Definition: When the containers are tilted, birds fall onto the conveyor. If the belt speed is not adapted, bunching (e.g. piling up of birds on the top of each other) might occur and lead to injuries.

Process of slaughtering to which it applies: Handling and removing of birds from crates or containers.

Hazard's preventive and corrective measures: As animals are tipped onto a conveyor belt, the design, position and speed of the equipment should be adapted to the throughput rate of the containers to prevent this hazard. The corrective measure could be to synchronise the speeds of the conveyor belts.

3.6.2. List of hazards during Phase 2 – stunning

The hazards listed in this section apply to conscious birds before stunning, to birds that have been ineffectively stunned, and to birds that recover consciousness after being stunned.

3.6.2.1. Manual restraint

Definition: Operators catch and immobilise the bird by hand. A key point in manual restraint is identifying an optimal pressure: as best practice, birds should be manually restrained firmly enough to facilitate the stunning, but without excessive pressure that would cause pain and fear. Poor manual restraint can lead to misapplication of the stunning method.

Process to which it applies: Restraint for: captive bolt, percussive blow and cervical dislocation, head-only electrical stunning and slaughter without stunning.

Hazard's preventive and corrective measures: No prevention/correction is possible for this hazard because it is part of the method. However, to minimise pain and fear, the restraint should be done with one hand covering both wings and the other holding both legs and supporting the breast (see Figure 14).

Alternatively, the operator can place both hands over the bird's wings and, once the bird is under control, slide one hand under its body, grasping its legs between the fingers and supporting its breast on the palm. The bird's wings can be controlled with the other hand or by holding it under the arm. The bird's head is then accessible for stunning. Smaller birds can be restrained by lifting them and holding by both legs.



Figure 14: Manual restraint performed with two hands in a careful and gentle manner (European Commission, 2018b)

3.6.2.2. Inversion

Definition: This is a restraining method that involves holding birds in an upside down position.

This can be done manually (e.g. for application of the mechanical methods) by inserting each leg into a shackle (e.g. before applying water-bath stunning – this form of restraint causes additional welfare consequences due to shackling – see following section) or inserting the bird into a cone (e.g. for some applications of head-only electrical stunning).

As birds do not have diaphragms, inversion can provoke compression of the heart and lungs by the viscera and might compromise breathing and cardiac activity. This might cause pain and fear in conscious birds.

Processes of slaughtering to which it applies: Restraint for head-only and water-bath electrical stunning, captive bolt, percussive blow, cervical dislocation or slaughter without stunning.

Hazard's preventive and corrective measures: No preventive measures exist, except to avoid inversion of conscious animals. No measures correcting the hazard exist.

3.6.2.3. Shackling

Definition: It is a restraining method that involves hanging birds upside down by inserting both legs into metal shackles. During shackling, the birds are also subjected to compression of their legs and wing flapping by their neighbour(s), if any.

Hanging upside down: This is a physiologically abnormal posture for chickens, and rough handling, inversion and shackling are practices that cause negative welfare consequences in birds such as pain and fear. For these reasons, approximately 90% of birds flap their wings immediately after shackling, and 66% flap their wings during any unevenness they experience in the line (Kannan et al., 1997). It is likely that such wing flapping could lead to dislocated joints and/or broken bones; this has not been quantified. However, it has been shown that these vigorous movements can lead to haemorrhages of the wing tip (Shields and Raj, 2010a,b).

Bedanova et al. (2007) found, as would be expected, that blood physiological stress parameters increased with increasing duration of broilers being hung upside down on a shackle line.

Compression of the legs: Sparrey and Kettlewell (1994) calculated that shackling could produce a force on each leg of the bird of 180 N applied over an area of 1 cm². The slot size of the shackle is particularly important because broilers show variable leg sizes, with males having consistently larger legs than females. The pressures required to compress broiler legs into shackles increases exponentially with deformation, and it requires four times as much pressure to compress a 14.5-mm leg by 20% to fit into an 11.5-mm shackle as it does to compress the same leg by 10% to fit into a 13-mm shackle (Sparrey, 1994). It is possible that these forces acting over relatively small areas of the leg would cause pain to the birds and the welfare concerns of shackling have been reviewed by Sparrey and Kettlewell (1994) and Gentle and Tilston (2000).

Wing flapping by adjacent bird(s): If a flapping bird hits the adjacent bird(s) with its wings, the neighbour(s) may also be disturbed and begin flapping. Fast line speeds may cause birds to notice inclines, to swing round any corners (if corners exist in the shackle line) and to lose contact with the breast contact strip, initiating wing flapping.

Processes of slaughtering to which it applies: Restraint for head-only and waterbath electrical stunning, and bleeding during slaughter without stunning.

Hazard's preventive and corrective measures: Prevention would be to avoid shackling of conscious animals but there is no real way to prevent or correct shackling, however, as it is a part of some of the stunning methods most commonly used in slaughter plants.

The measures proposed here are just best practices to decrease to the minimum the negative welfare consequences that shackling birds can cause.

Birds shackled after stunning should be monitored for absence of signs of consciousness before shackling.

Shackle lines must be constructed and maintained so they do not jolt birds as this is likely to stimulate flapping. Shackle line speeds must be optimised such that they do not cause the birds to struggle. Empty shackles may be wetted just prior to shackling birds to improve electrical conductivity, and measures such as provision of breast supports help to minimise wing flapping.

Birds with large shanks tend to struggle more violently than those with smaller shanks. Satterlee et al. (2000) showed that male birds are heavier and have significantly thicker shanks than females; they also struggle sooner after shackling and for longer duration. Males and female data combined, circumference of the shank was negatively correlated with latency to struggle and positively associated with number of struggling bouts and total time spent struggling. However, there were no detectable correlations within sex. Body weight was not significantly correlated with any of the struggling behavioural measures. Satterlee et al. (2000) concluded that use of shackles of fixed size may contribute to increased struggling behaviour in male broilers.

To minimise wing flapping, breast support can be provided to the birds and should be present from the shackling point to the stunner. An example is the use of a conveyor running underneath the shackle line on which the birds to rest on their breasts, supported on a horizontal conveyor with their legs extended behind them and engaged in shackles. The birds are transported in this way from the point at which they are shackled to the point at which they are stunned. In the case of waterbath stunning, the conveyor ends at the waterbath entrance, the birds swing off at the end of the conveyor and their heads fall directly and rapidly into the electrical waterbath (Lines et al., 2012). The breast-support conveyor appears to be a practical concept that improves the welfare of broilers on a shackle line by reducing struggling and promoting a cleaner entry into the proper stunning/killing process (e.g. the waterbath). The conveyor could also provide a further welfare benefit by allowing the time from hang-on to stunning to be reduced as the birds do not require time to settle. Processing lines that run in a straight line from hang-on to the stunning/killing process could introduce this equipment with relatively few other modifications; however, it does not seem to be suitable for lines with corners. The most important additional modification, which may be needed to enable the breast-support conveyor to be used safely, is the introduction of leg guards or other measures to prevent the birds from disengaging their legs from the shackle (Lines et al., 2012).



Figure 15: Compliant shackle (left) and standard plant shackle (right) installed in a processing plant. Reprinted by permission from: Universities Federation for Animal Welfare (UFAW), Lines et al., 2012

3.6.2.4. Inappropriate shackling

Definition: Within the shackling procedure, inappropriate shackling can also occur in several situations, such as when the shackles are too narrow or too wide, when the birds are hung by one leg, or when one bird is shackled on two different adjacent shackles.

Processes of slaughtering to which it applies: Restraint for head-only and water-bath electrical stunning, and bleeding during slaughter without stunning.

Hazards' preventive and corrective measures: Considering the relevant literature cited above, an important preventive measure is to ensure that the size and design of the shackle is appropriate for the bird size, i.e. not exceeding a 10% compression of the animal's legs (Sparrey, 1994). An animal should be appropriately shackled in the manner described above, which, at a minimum, requires that the number of people shackling is sufficient to match the line speed. In slaughterhouses, it is considered that each person can shackle up to 1,000 birds per hour in purpose-built conditions where high throughput rates are required. A slaughterhouse killing 10,000 birds per hour will engage 10 skilled people to achieve this throughput and the shackle line will be long enough for them to stand side-by-side as they work. In addition, the live bird shackling area will have bird calming measures (e.g. dim blue light) that include breast support extending from the point of shackling to the entrance to the water bath.

There are conflicting bird welfare concerns regarding the use of tight-fitting shackles. Although they may provide good electrical contact with the legs and metal shackles, they are likely to increase the severity of the pain associated with shackling (Sparrey and Kettlewell, 1994), especially with regard to occurrence of bruising of the surface of leg and thigh muscles. To fix that, Lines et al. (2012) tested compliant shackles designed to avoiding compression of the birds' legs while still maintaining good electrical contact. The compliant shackles developed for testing were based on shackles already in use but had only a single pair of slots, the inner rails of which were free to move in response to leg width. To ensure the shackle remained robust, the maximum slot width was limited, and the moving rails were held captive on the bottom rail (Figure 15).

In addition, conscious birds with injuries may be shackled (e.g. those with diseases or abnormalities of (leg/wing) joints or bones and those with (leg/wing) dislocated joints or bone fractures). This exacerbates the welfare consequences of shackling conscious birds. Shackling has been reported to be painful (Gentle, 1992; Gentle and Tilston, 2000) and the pain associated with it is likely to be worse in birds with severe leg abnormalities or joint illness. Therefore, as best practice, birds that are visibly injured, those with severe leg abnormalities and runts that are likely to miss the waterbath should not be shackled. Instead they should be killed immediately using an appropriate method.

Inappropriate shackling can be prevented by training staff to handle birds with care and compassion, shackling birds gently by both legs, killing injured birds before shackling, by rotating staff at regular intervals to avoid boredom and fatigue and by using shackles that are appropriate to the species and size of the birds.

3.6.2.5. Drops, curves and inclination of shackle line

Definition: The moving shackle line may include sharp curves, inclinations, drops and bunched transitions, causing irregular movements that can increase the force the shackles exert on the legs of the animals. The irregular movements and increased force on the legs can lead to painful compression and a fear response.

Process of slaughtering to which it applies: Restraint for head-only and waterbath electrical stunning and slaughter without stunning.

Hazard's preventive and corrective measures: No prevention/correction measures have been identified other than redesign of the shackle line to avoid this hazard.

3.6.2.6. Pre-stun shocks

Definition: The bird experiences electric shocks before the onset of unconsciousness.

Pre-stun shocks usually occur when the leading wing or any part of the bird other than the head touches the water of the electrical waterbath before the bird is effectively stunned (DEFRA, 2007; Shields and Raj, 2010a,b; Rao et al., 2013). Wing flapping at the entrance to the waterbath makes likely the occurrence of pre-stun electrical shocks (EFSA, 2004). Pre-stun shocks can also occur when electrically live water overflows out of the waterbath stunners and on to the entry ramp (HSA, 2006). Pre-stun shocks lead to wing flapping and may cause the bird to lift its head and miss the waterbath stunner completely (referred to in the literature as 'flying the stunner'). In this situation, conscious birds will reach the end of the process without being killed. This is a problem because, in the absence of welfare monitoring at key stages during slaughter of poultry (EFSA AHAW Panel, 2013) and proper implementation of a backup stunning procedure, birds may be disposed of when still alive and conscious.

Process of slaughtering to which it applies: Waterbath electrical stunning.

Hazard's preventive and corrective measures: Because wing flapping at the entrance to the waterbath leads to pre-stun shocks, measures calming the birds or reducing the frequency of wing flapping can be put in place to prevent this hazard. These could include breast rubs, low lighting, smooth transition into the waterbath and gentle shackling that does not trigger wing flapping.

Proper waterbath design, including a nonconductive entrance (e.g. an electrically isolated entry ramp), will also help eliminate pre-stun shocks (AVMA, 2016). The preventive measures are linked to the level of water in the waterbath: in an optimal setting, birds are immersed up to the base of their wings. The presence of an electrically insulated/isolated entry ramp can minimise overflow of the water at the entrance of the waterbath (HSA, 2015, European Commission, 2017b, 2018b).

There is no corrective measure that can be applied after the shocks have occurred.

3.6.2.7. Poor electrical contact

Definition: The electric contact is too weak to facilitate flow of sufficient current to immediately stun the birds. It may occur:

- in the case of waterbath stunning, between legs and shackle or between shackles and the earthing bar;
- in the case of head-only electrical stunning, between electrodes and head. This can result from: (a) incorrect placement of the electrodes such that they do not span the brain; (b) an intermittent contact; and (c) the use of dirty/worn electrode(s).

In the case of intermittent contact, repeated use, poor maintenance, and lack of replacement of metal shackles can lead to corrosion, increasing resistance to current flow and causing localised heat generation. In waterbath stunning, unclean shackles can disturb the electrical contact, meaning the desired level of current flow through the brain is not achieved.

Dirt (originating from e.g. the birds' plumage or carbonised debris) may accumulate on the electrodes, leading to increased resistance to current flow. In waterbath stunning, accumulation of fat will lead to increased electrical resistance of the electrodes.

Processes of slaughtering to which it applies: Waterbath and head-only electrical stunning.

Hazard's preventive and corrective measures: For head-only electrical stunning, ensuring correct presentation of the birds and that the equipment includes electrodes for different-sized animals so that the current will flow easily through the brain. Electrodes must be properly constructed to ensure contact with skin through the bird's feathering. Placing water on the head of the bird reduces resistance. Four options are available for correct electrode placement for the head-only method: on both sides of the head, between the eye and ear, at the base of the ear on both sides of the head, or diagonally below one ear and above the eye on the opposite side of the head (AVMA, 2016).

In the case of waterbath stunning, cleaning and disinfection of the equipment might prevent poor electrical contact. Shackles should be routinely cleaned using an appropriate detergent, empty shackles should be wetted before reaching the live bird shackling area, and the earthing bars should be routinely cleaned (see also Section 3.6.2.3. Shackling).

3.6.2.8. Too short exposure time

Definition: For electrical stunning methods, the duration of exposure to the electrical current is too short to result in epileptiform activity in the brain; for CAS, the time of exposure is too short to induce unconsciousness in all birds in the applied atmosphere.

In both cases, it might also be that the period of unconsciousness after stunning is too short to prevent recovery of consciousness during bleeding.

Processes of slaughtering to which it applies: Waterbath and head-only electrical stunning, CAS including LAPS.

Hazard's preventive and corrective measures: Measures to maintain or increase adequate exposure times will prevent or correct this hazard. This is a matter of setting an appropriate line speed for the capacity of the slaughterhouse (see Tables 13–16).

Regarding the electrical stunning methods, staff training and optimising the throughput rate can be adequate to ensure a sufficient exposure of the birds.

In LAPS, following the specifications for the couple time/target pressure should avoid this hazard.

3.6.2.9. Inappropriate electrical parameters

Definition: The electrical parameters (i.e. voltage, current, frequency, waveforms) fail to achieve epileptiform activity in the brain. This is caused by e.g. voltage that is too low to generate sufficient current to achieve an effective stun, frequency that is too high to cause immediate unconsciousness, or electrical resistance of the bird too high to prevent enough current flow through the brain to cause immediate unconsciousness.

Processes of slaughtering to which it applies: Waterbath and head-only electrical stunning.

Hazard's preventive and corrective measures: No measures have been identified to correct this hazard.

To prevent this hazard, appropriate parameters need to be determined and applied.

For head-only electrical stunning, the main parameter that needs to be taken into account is the minimum current delivered to the birds, which depends upon the output voltage of the equipment (Raj and O'Callaghan, 2004a). The minimum current required to achieve effective stunning of chickens and turkeys is reported in Section 3.2.1.2. However, to ensure the voltage is sufficient to deliver that minimum, the responsible person of the slaughterhouse should, as a best practice, evaluate the equipment using a small fraction of the population of birds and looking for signs of consciousness. In this evaluation process, the factors that could contribute to high electrical resistance in the pathway (e.g. density of feathers and bones, design and construction of the electrodes) should be identified, and ways of minimising or eliminating them explored (e.g. wetting of the heads with a wet sponge, selecting materials and designs that offer the least electrical resistance) (HSA, 2013). Another way of overcoming the problem of high resistance is using a constant-current stunner. For example, equipment capable of delivering a pre-set constant current using variable voltages to overcome resistance in the pathway has been developed (Sparrey et al., 1993) and tested (Raj and O'Callaghan, 2004a; Lambooij et al., 2010). Implementation of such equipment would greatly benefit poultry welfare at slaughter. It is worth mentioning that the effectiveness of the head-only electrical stunning has been shown to be dependent on the frequency of the current used (Raj and O'Callaghan, 2004a). Similarly, the minimum current necessary to achieve effective water-bath stunning varies with the frequency of current used and the species (Raj and O'Callaghan, 2004b; Raj et al., 2006a,b).

In waterbath stunning, the parameters used in the EU and stipulated in the OIE guidelines (OIE, 2016) are presented in Table 2 (Section 3.2.1.1). However, additional information on the minimum parameters that should be applied to ensure effective stunning. To ensure the voltage is sufficient to

deliver the minimum current to each bird in the waterbath, the operator needs to calculate the total amount of current (mA) necessary on the basis of the frequency indicated in Table 2 and multiply it for the capacity (no. of birds) of the waterbath stunner. The voltage can then be adjusted accordingly. For example, if 100 mA per bird is required and 10 chickens are in the waterbath at any one time, the total current necessary can be calculated by multiplying $100 \text{ mA} \times 10 = 1 \text{ Amp}$. In addition, the operator should take into consideration the usual electrical resistance of the species of poultry to be stunned. Different values for electrical resistance are reported in the Guidance produce by the Humane Slaughter Association (HSA, 2015). There are also commercially available electronic stun monitors that could be used to set up the electrical parameters and verify whether the equipment is functioning properly (HSA, 2015). The responsible person at the slaughterhouse should regularly calibrate and maintain the equipment to ensure the minimum current required is attained in every case.

In addition, as a good practice, the over- and under-sized animals (as compared with the average size of the flock) should be discarded and slaughtered in batches of similarly sized animals (or with a back-up method) to ensure all birds receive sufficient stunning current.

For electrical waterbath stunning of poultry, it is recommended that sine wave AC of no higher than 600 Hz is delivered for a minimum of 4 s and with an average current of 100 to 400 mA, depending on the species and the frequency (see Table 2).

3.6.2.10. Inability to deliver minimum current to all the birds

Definition: With multiple birds waterbath, each bird may not receive the same current and, for some birds, it might be not sufficient to induce unconsciousness. This is because the method is not capable of coping with biological variations among birds.

Process of slaughtering to which it applies: Waterbath electrical stunning.

Hindle et al. (2010) made an inventory of electrical stunning parameters used in 10 slaughterhouses in the Netherlands. Laboratory experiments were carried out using a single-bird water-bath stunning to examine the effects of stunner settings based on the average technical settings observed in the slaughterhouses. Responses were recorded at 50, 400-, and 1,000 Hz on broilers and hens, and at 50 and 400 Hz on ducks under controlled laboratory conditions. Effects of voltage settings (broilers: 100–400 V; hens: 150–300 V; ducks: 150–400 V) on current levels (broilers: 45–444 mA; hens: 40–219 mA; ducks: 64–362 mA) and consciousness (response to pain stimulus) were recorded immediately after stunning. Brain and heart activities were monitored using electroencephalogram and electrocardiogram technologies. The results showed that effective stunning using the conventional waterbath almost exclusively produces blood splashing in broilers. Effective stunning current levels did not differ significantly between broilers, hens and ducks, whereas effectively stunning hens tended to require lower currents. Effective stunning at higher frequencies required higher currents. Similar input voltage levels (within and between bird types) resulted in significant variation ($p < 0.001$) in current levels required for an effective stun, indicating variability in electrical impedance between individual birds.

Hazard's preventive and corrective measures: To prevent this hazard, it is suggested to make flocks of birds as homogeneous as possible and to set the electrical parameters of the waterbath to allow each bird in the multiple waterbath to receive the minimum current required to induce unconsciousness.

3.6.2.11. Exposure to too high CO₂ concentration

Definition: Conscious birds are exposed to CO₂ concentrations higher than 40%. This can occur due to high CO₂ concentration ($> 40\%$) in the first phase of the gas stunner or when birds enter the second phase of the CO₂ stunning system while they are still conscious. This could also occur due to a combination of too low CO₂ concentration and too short exposure time in the first phase leading to animals arriving conscious in the second phase in which CO₂ is above 40%.

Process of slaughtering to which it applies: Gas stunning methods.

Hazard's preventive and corrective measures: It has been shown that birds find CO₂ in concentrations higher than 40% aversive and, given a free choice, they avoid such atmospheres (see EFSA, 2004, for details). Exposing conscious birds to a concentration of CO₂ higher than 40% should therefore be avoided. (this is mandatory in Council Regulation (EC) No 1099/2009, for example).

Prevention of this hazard relies on proper monitoring of gas concentration and its maintenance below 40% during the induction of unconsciousness. If the concentration is above 40%, a corrective measure is to inject air to reduce the concentration to below 40%.

3.6.2.12. Too low concentration of gas

Definition: The gas concentration is too low to render all birds unconscious within the applied time of exposure or to prevent recovery of consciousness during bleeding.

Low CO₂ concentrations will prolong the induction of unconsciousness, leading to prolonged respiratory distress.

Process of slaughtering to which it applies: Gas stunning methods.

Hazard's preventive and corrective measures: It is important to adequately monitor the gas to maintain the required concentration at the level of birds (breathed by the birds) and keep injecting gas until the required levels are reached. The gas is vaporised before injection and its temperature monitored (see also relevant outcome table (Table 15)).

3.6.2.13. Too fast decompression

Definition: The decompression rate must not be greater than or equivalent to a reduction in pressure from standard sea level atmospheric pressure (760 Torr) to 250 Torr in not less than 50 s. Reaching 250 Torr in less than 50 s or a lower pressure in 50 s is considered too fast decompression. During a second phase, a minimum atmospheric pressure of 160 Torr shall be reached within the following 210 s.

A too fast decompression rate is associated with induction of pain and respiratory distress.

Process of slaughtering to which it applies: LAPS.

Hazard's preventive and corrective measures: As a prevention, no faster decompression should be applied than the one described above and in the LAPS process (Section 3.2.2.4).

3.6.2.14. Expansion of gases in the body cavity

Definition: The decompression applied to the birds inside the chamber might lead to expansion of gases in body cavity such as in the gut, although no evidence was found in experiments performed on the LAPS. The welfare consequences of gas expansion have not been elucidated during the assessment of the LAPS system carried out by EFSA AHAW Panel (2017). It is known that rupture of the intestine due to gas expansion does not occur during LAPS (EFSA AHAW Panel, 2017), but no data are available to rule out the possibility of colic-like pain occurring in conscious poultry during the first phase of LAPS. The absence of proof in the literature should not be considered for now as a proof of absence of this specific hazard.

Since LAPS is not currently in place, this hazard could be only presumed to occur, but there is a level of uncertainty that cannot be ignored and needs to be highlighted mainly if, in the future, LAPS becomes a common practice.

Process of slaughtering to which it applies: LAPS

Hazard's preventive and corrective measures: None (see Table 16).

3.6.2.15. Incorrect shooting position

Definition: When the captive-bolt is positioned wrongly, unconsciousness of the birds might be not achieved. The captive-bolt should be pointing perpendicularly on the parietal bones of birds.

In a study by Raj and O'Callaghan (2001), 19 broilers aged 6–7 weeks (live weight (mean \pm SD) = 2.9 \pm 0.20) were used to evaluate the effect of captive bolt shooting at 90° (perpendicular to the skull, n = 10), 110° (n = 3), 120° (n = 3) or 130° (n = 3) angles. The diameter of the bolt, air line pressure and penetration depth were 6 mm, 827 kPa and 10 mm, respectively. The results showed that, compared with perpendicular shooting, non-perpendicular shooting failed to stun a significant proportion of the broilers tested and did not cause immediate death in any of them. Shooting broilers with a 6-mm diameter bolt at 90° with an air line pressure of 827 kPa resulted in immediate cessation of breathing and loss of neck muscle tension and eye reflexes. All the birds showed severe convulsions (wing flapping and leg kicking) immediately after shooting. None of the broilers survived this treatment. When the captive bolt was shot at 110°, 120° or 130°, the majority of birds (5 out of 9) survived, continued breathing and showed no convulsions.

Process to which it applies: Captive bolt stunning.

Hazard's preventive and corrective measures: Captive bolt should be pointed perpendicularly to the parietal bones of birds. This requires training of staff and use of an appropriate restraint.

3.6.2.16. Incorrect captive bolt parameters

Definition: The bolt parameters fail to effectively stun birds and render them unconscious. It is caused by e.g. low air line pressure, low cartridge power, low bolt velocity, shallow penetration and faulty equipment (too narrow bolt diameter).

Raj and O'Callaghan (2001) suggested that the appropriate variables for captive bolt stunning of broilers are a minimum of 6-mm bolt diameter driven at an air line pressure of 827 kPa and a penetration depth of 10 mm. In this study, shooting broilers with a 3-mm bolt at air line pressures of 620 kPa ($n = 2$) or 827 kPa ($n = 2$) failed to stun as indicated by the unaltered physical reflexes, EEG and VEPs. Shooting of two broilers with a 6-mm bolt at 620 kPa resulted in effective stunning and a very rapid recovery of consciousness in one bird and death in the other. Similarly, Gibson et al. (2018) evaluated three different commercially available non-penetrating captive bolt guns in turkeys and reported that accurate shooting and enough cartridge power are critical to achieving effective stunning.

Process of slaughtering to which it applies: Captive bolt stunning.

Hazard's preventive and corrective measures: Use equipment fit for the purpose.

3.6.2.17. Incorrect application of blow to the head and cervical dislocation

Definition: When the birds are hit in the wrong place or with a force not sufficient to cause brain concussion.

In the case of cervical dislocation, it may happen due to:

- a too slow stretching or twisting of the neck: manual or mechanical separation of spine from the head should be carried out quickly and firmly in one continuous motion (European Commission, 2017b, 2018b);
- the lack of separation of the brain and spinal cord, in which the brain and spine may be intact or there is incomplete separation or crushing of the spine;
- the incomplete severance of the carotid arteries leading to death: the failure to completely sever both carotid arteries meaning the brain will continue to receive a supply of oxygenated blood.

Although direct scientific evidence is lacking, expert opinion expressed in a previous EFSA opinion (EFSA, 2006) states that death is not instantaneous in the case of cervical dislocation and that the inflicted tissue damage may be perceived as painful. Cervical dislocation should therefore only be used as backup method.

Processes of slaughtering to which it applies: Percussive blow and cervical dislocation.

Hazard's preventive and corrective measures: Staff training on the correct use of cervical dislocation: use both stretching and twisting so that the spinal cord is separated from the brain and the carotids are severed ensuring the brain is not supplied with oxygen.

In the case of percussive blow, it is important to place the head of the bird on a hard surface before delivering the blow.

3.6.3. List of hazards during Phase 3 – bleeding

In the case of bleeding following stunning, the hazards apply only to birds that are conscious due to ineffective stunning or recovery of consciousness following stunning.

The hazards that may lead to recovery of consciousness in birds during bleeding after stunning are: prolonged stun-to-neck-cut interval and incomplete sectioning of carotids.

The hazards that may lead to persistence of consciousness are those causing ineffective stunning (e.g. inappropriate electrical parameters, see hazards during Phase 2, Section 3.6.2).

When birds are conscious (e.g. all birds subjected to bleeding during slaughter without stunning; some birds ineffectively stunned or recovering consciousness following stunning), they will experience the negative welfare consequences (i.e. pain) due to the bleeding process.

The hazards below in Sections 3.6.3.2–3.6.3.7 apply to all conscious animals; the hazards in Section 3.6.3.1 will apply only to animals bled after stunning because it leads to recovery of consciousness.

All birds bled during slaughter without stunning will be submitted to the hazards described below in Sections 3.6.3.2–3.6.3.7, whereas only a proportion of birds bled following stunning application will experience them only when the stunning process fails due to the following circumstances:

- birds are ineffectively stunned or recover consciousness;
- the state of consciousness is not properly monitored at key stages;
- the back-up stunning systems are not implemented.

3.6.3.1. Prolonged stun-to-neck-cut interval

Definition: The interval between the end of stunning and neck cutting is too long to sustain unconsciousness until death occurs due to bleeding.

This is a hazard leading to recovery of consciousness. This will occur in plants with a long interval between the stunner and the neck cutter.

Process of slaughtering to which it applies: Bleeding following stunning (on a proportion of birds).

Hazard's preventive and corrective measures: The time of this interval should be reduced to prevent recovery of consciousness (see relevant outcome table (Table 20)). For example, in the case of water-bath stunning, this could be achieved by positioning the neck cutting machine or staff close to the exit of the water-bath stunner. In any event, stun-to-neck-cutting interval should not exceed 10 s, especially when using high electrical frequencies for waterbath stunning (HSA, 2015).

When neck cutting machines are used, a manual backup should be positioned next to the machine to perform neck cutting, if required.

No corrective measures exist without changing facilities' structure.

3.6.3.2. Incomplete sectioning of carotids

Definition: Failure to cut both carotid arteries to prevent oxygenated blood supply to the brain.

In bleeding following stunning, this hazard can lead to recovery of consciousness. For example, Raj et al. (2006a) reported that when one carotid artery and one jugular vein were severed during neck cutting of broilers that were effectively stunned in a waterbath, the average time to the onset of an isoelectric EEG was 50.4 ± 25.60 s. This was reduced to 22.7 ± 6.68 s when two carotid arteries and two jugular veins were cut. Incomplete section of carotids therefore delays the onset of death.

In slaughter without stunning, the time to onset of unconsciousness and death will be prolonged.

Processes of slaughtering to which it applies: Bleeding following stunning (on a proportion of birds) and bleeding during slaughter without stunning (100% of birds).

Hazard's preventive and corrective measures: Training of staff and the setting up of equipment to ensure both carotids are completely cut and brain is not supplied with oxygen (see also Tables 20 and 21).

3.6.3.3. Neck cutting

Definition: incision of skin, soft tissues, nerves and blood vessels in the neck of poultry.

In bleeding following stunning, it applies only to birds remaining conscious or recovering consciousness.

In bleeding during slaughter without stunning, this hazard is a part of the method and therefore applies to all birds.

Processes of slaughtering to which it applies: Bleeding following stunning (on a proportion of birds) and bleeding during slaughter without stunning (100% of birds).

Hazard's preventive and corrective measures: in the case of bleeding following stunning, good stunning practices (including monitoring of stunning and use of back-up methods if needed) will prevent this hazard; in the case of bleeding during slaughter without stunning, there is no prevention because this is a part of the method.

No corrective measures exist.

3.6.3.4. Repeated cuts

Definition: Multiple application of neck cuts.

When birds are slaughtered without stunning, repeated cuts correspond to sawing movement with a knife. When birds are bled after stunning, repeated cuts might happen when both carotids are not severed during the first intervention.

Processes of slaughtering to which it applies: Bleeding following stunning (on a proportion of birds), bleeding during slaughter without stunning (100% of birds).

Hazard's preventive and corrective measures: In the case of bleeding following stunning, good stunning practices (including monitoring of stunning and use of back-up methods if needed) and training of the staff to adequately sever carotids will prevent this hazard; in the case of bleeding during slaughter without stunning, there is no prevention because this is a part of the method.

No corrective measures exist.

3.6.3.5. Stimulation of wound

Definition: Physical stimulation of the tissues and nerve endings in the cut surface. It mainly occurs due to the restraint or manipulation.

Processes of slaughtering to which it applies: Bleeding following stunning (on a proportion of birds) and bleeding during slaughter without stunning (100% of birds).

Hazard's preventive and corrective measures: Avoid manipulation or physical contact with the wound.

No corrective measures exist.

3.6.3.6. Bleeding to death

Definition: Inducing gradual loss of consciousness and death due to bleeding.

Processes of slaughtering to which it applies: Bleeding following stunning (on a proportion of birds) and bleeding during slaughter without stunning (100% of birds).

Hazard's preventive and corrective measures: In the case of bleeding following stunning, good stunning practices (including monitoring of stunning and use of a back-up method if needed) and training of the staff to adequately sever carotids will prevent this hazard. In the case of bleeding during slaughter without stunning, there is no prevention because this is a part of the method.

No corrective measures exist.

3.6.3.7. Birds entering the scalding tank alive

Definition: Birds with signs of life undergoing the scalding tank.

Live birds can enter the scalding tanks under several scenarios:

- birds that are inadequately stunned or have missed the stunner (due to wing flapping or being runts) are very likely to avoid the neck cutter by holding their heads up;
- in the case of slaughter without stunning, when birds are subjected to a poor neck cut, they may remain alive and possibly conscious when entering the scalding tank;
- occasionally, effectively stunned birds also miss the neck cutting machine because they miss the rails that guide the neck towards the blade(s). If these birds are not neck-cut with a back-up method (e.g. manually), they will enter the scalding tank alive and conscious. Adequately stunned birds could also have a poor neck cut and enter the scalding tank alive but unconscious.

Although legislation in the EU requires that a manual back-up should be present to cut the necks of birds that missed the neck cutter, fast throughput rates mean manual back-up alone is not sufficient to prevent this potential welfare problem.

The potential welfare problem of live birds entering the scalding tanks, recognised by the occurrence of 'red-skin' carcasses (as an ABM), was reported to be the result of poor slaughter procedures (Harris and Carter, 1977). In the 1980s, it was reported that almost one-third of the birds processed under commercial conditions may have entered scald tanks alive (Heath et al., 1981; Griffiths and Purcell, 1984). Heath et al. (1983) suggested that red-skin carcasses were produced from poultry that were alive when they entered the scald tanks; this was later confirmed experimentally by Griffiths (1985) to be the consequence of an acute inflammatory reaction. In recent years, the potential for this problem to occur has increased due to the use of low currents (Amp) at high frequency (Hz) in the waterbath and significant increases in throughput rates.

Processes of slaughtering to which it applies: Bleeding following stunning (on a proportion of birds) and bleeding during slaughter without stunning (100% of birds).

Hazard's preventive and corrective measures: This hazard raises bird welfare and/or ethical concerns.

To prevent it, it is important to ensure proper monitoring of consciousness and death during key stages of slaughtering (EFSA AHAW Panel, 2013; Raj and Velarde, 2016), and ensuring death of the animal before it enters the scalding tank is the only way to be sure that no bird will recover consciousness while being processed. Backup stunning and backup neck cutting should be performed in case birds miss the neck cutter (EFSA, 2004).

Once the bird has entered the scalding tank alive, no corrective measures exist.

3.6.4. Considerations on the hazards and their distribution

The exposure to some hazards might persist through processes and phases until the birds are unconscious (e.g. food and water deprivation) (see Tables 9–12). An overview of the hazards

described in the different processes of Phase 1 is shown in Table 3. Other hazards might be present only during one phase, but the welfare consequences might persist during the following phases (e.g. pain due to rough handling). Furthermore, some hazards in Phase 2 are specific to the stunning method applied (see Tables 13–19). An overview of the hazards described in the different processes of Phase 2 is shown in Table 4).

It is to be noted that combination of hazards may exacerbate some animal welfare consequences. A combination exists when several factors are contributing to the same welfare consequence. For example, it is well described that rough handling increases the risk of leg and wing fractures and haematomas of legs and wings. During shackling, birds are subjected to compression of their legs and wing flapping by their neighbours. Injured animals subject to rough handling will experience more pain during shackling. In this case, the consequence of exposure to the two hazards will be greater than the sum of the consequences of the two hazards present separately (EFSA AHAW Panel, 2012a).

Table 3: Overview of hazards during Phase 1 (see Section 3.6.1)

Hazard	Arrival	Unloading of containers	Lairage	Handling and removing of birds from crates or containers
Too high effective temperature	x		x	
Too low effective temperature	x		x	
Insufficient space allowance	x		x	
Food deprivation too long	x		x	
Water deprivation too long	x		x	
Rough handling of containers		x		
Jamming or crushing heads, wings and legs in containers		x		
Unexpected loud noise			x	
Rough handling of the birds during removal from the containers				x
Tipping or dumping on conveyors				x
Bunching on the conveyor belts				x
Total no. of hazards	5	2	6	3

It should be noted that some of the hazards identified for these steps are indeed combinations of hazards. For example, 'too high effective temperature' can be the result of high temperature and humidity in the environment where the animals were placed combined with too high stocking density (Chauvin et al., 2011) and limited wind (no active mechanical ventilation).

Additionally, some of the hazards identified through the literature search and the exercise during the NCP meeting (see Sections 2.2.1 and 2.2.2) have, after WG discussion, been removed from the final list reported in the outcome tables, as is the case for prolonged time of waiting at arrival or lairage, which the experts recognised as having a role in making some other hazards worse (e.g. the effect of too high effective temperature or of food/water deprivation too long at arrival and at lairage is exacerbated when combined with prolonged time of waiting), but not being an hazard *per se*. It is indeed clear that the duration of a process influences the effects of the hazards. The origin of a prolonged lairage duration could be in the planning of transport arrival (catching and journey time not well predicted), the planning of the slaughter schedule (too many flocks to slaughter at the same time), or in a technical issue (failure in the slaughter process inducing delay). In this sense, 'unload immediately' and 'reduce waiting time to unloading and lairage' are important actions to reduce or mitigate the welfare consequences of a hazard, but they are not measures aimed at cancelling the hazard.

Of course, hazards recognised as such, like insufficient space allowance at arrival, can increase or temper the effects of other hazards. When a combination of hazards occurs (sometimes combined with weak animals/bad transportation conditions), the birds' welfare troubles can lead to death, which is reflected in 'death on arrival' (DoA, see Sections 3.1 and 3.7.2).

Table 4: Overview of hazards during the diverse methods of Phase 2 (see Section 3.6.2)

Hazard	Methods						
	Waterbath	Head-only	Gas	LAPS	Captive Bolt	Percussive blow	Cervical dislocation
Manual restraint		X			X	X	X
Inversion	X	X			X	X	X
Shackling	X	X					
Drops, curves and inclination of shackle line	X	X					
Inappropriate shackling	X	X					
Pre-stun shocks	X						
Poor electrical contact	X	X					
Too short exposure time	X	X	X	X			
Inappropriate electrical parameters	X	X					
Inability to deliver minimum current to all the birds	X						
Exposure to too high CO ₂ concentration			X				
Too low concentration of gas			X				
Too fast decompression				X			
Expansion of gases in the body cavity				X			
Incorrect shooting position					X		
Incorrect captive bolt parameters					X		
Incorrect application of blow to the head and cervical dislocation						X	X
Total No of hazards	9	8	3	3	4	3	3

3.6.5. Assessment of uncertainty

Uncertainty related to the occurrence of false-negative and false-positive hazards was assessed (see methodology described in Section 2.2.4).

Regarding the possible occurrence of false-negative hazards, the experts were 90–95% certain that they identified the main and most common welfare hazards considered in this assessment according to the three criteria described in the Interpretation of ToRs. However, when considering a global perspective, the experts were 95–99% certain that at least one welfare hazard is missing. This is due to the lack of documented evidence on all possible variations in the processes and methods being practiced on a worldwide scale (see Interpretation of ToRs on the criteria for selection of stunning/killing methods to be included).

Regarding the possible inclusion of false-positive hazards, the experts were 95–99% certain that all listed hazards exist during slaughter of poultry. This certainty applies to all processes described in this opinion except the hazard 'expansion of gases in the body cavity' during stunning with LAPS, where the lack of field experience and scientific data reduces the level of certainty to 33–66% (see Section 3.6.2.14).

3.6.6. Origin categories and specifications

On the basis of experts' knowledge, the origins of the hazards have been identified and categorised in terms of facilities/equipment or staff, as required by the mandate.

The category 'staff' includes all personnel involved in unloading, movement, restraint, stunning and slaughter of birds, including FBO and those responsible for bird welfare.

'Facilities' means permanent features, fixtures and fittings including layout, design and construction of the slaughterhouse and various associated structures/features intended for receiving, lairaging, stunning and slaughtering birds.

'Equipment' includes machinery or tools used on live birds for handling, moving, restraining, stunning and slaughter. For example, containers used for transporting birds, forklifts used for

unloading, shelter to protect birds and ventilation system in lairage, machines for removing birds from containers by tilting and shaking, shackle lines used for conveying birds to the stunner, stunning devices and associated calibrating and monitoring systems, automatic neck cutting machines or knives used for slaughtering birds.

Owing to the complexity of slaughter, some hazards, especially those in the pre-stunning phase involve all three origin categories, and some others identified in stunning and bleeding phases involve one or two categories (i.e. staff and equipment).

Poorly designed, constructed and maintained slaughterhouse facilities would result in recurring chronic problems and require investment to prevent hazards; some hazards in this category may have corrective measures and others may not.

'Staff' category contributes to most of the hazards. Almost all of the hazards originating from staff could be attributed to lack of the appropriate skill sets needed to perform tasks or to fatigue, and therefore have preventive measures that include recruitment of people with the right attitude and aptitude, staff training and staff rotation.

'Equipment' is an important category contributing to the second highest number of hazards in all the phases, especially during stunning.

Inevitably, preventive or corrective measures appropriate for a hazard will vary according to the origin category. The proportion of birds subjected to hazards could also vary according to the origin category.

An overview of the origin category(ies) pertaining to each of the hazards identified in the sections above is reported below in Tables 5–7.

Relevant origin specifications are reported in the outcome tables developed for each process of slaughtering (see Section 3.10).

Table 5: Overview of the origin categories relevant to the hazards identified for Phase 1

Hazards	Staff	Facility	Equipment
Too high effective temperature	x	x	x
Too low effective temperature	x	x	x
Insufficient space allowance	x		
Food deprivation too long	x		
Water deprivation too long	x		
Rough handling of containers	x	x	
Jamming or crushing of heads, wings and legs in containers	x		x
Unexpected loud noise	x	x	x
Rough handling of the birds during removal from the containers	x	x	x
Tipping or dumping on conveyors	x		x
Bunching on the conveyor belts			x

Table 6: Overview of the origin categories relevant to the hazards identified for Phase 2

Hazards	Staff	Facility	Equipment
Manual restraint	x		
Inversion			x
Shackling			x
Drops, curves and inclination of shackle line		x	x
Inappropriate shackling	x		x
Pre-stun shocks	x		x
Poor electrical contact	x		x
Too short exposure time	x		x ^(a)
Inappropriate electrical parameters	x		x
Inability to deliver minimum current to all the birds			x
Exposure to too high CO ₂ concentration	x		x
Too low concentration of gas	x		x

Hazards	Staff	Facility	Equipment
Too fast decompression	x		x
Expansion of gases in the body cavity			x
Incorrect shooting position	x		
Incorrect captive bolt parameters	x		x
Incorrect application of blow to the head and cervical dislocation	x		x ^(b)

(a): In the case of CAS, the origins can be staff and equipment; in the case of electrical methods, only staff has been identified as origin.

(b): In the case of mechanical cervical dislocation.

Table 7: Overview of the origin categories relevant to the hazards described in Phase 3, in the case of bleeding following stunning, and in Phases 2 and 3 in the case of bleeding during slaughter without stunning (including restraint)

Hazards	Staff	Facility	Equipment
Manual restraint ^(a)	x		
Inversion ^(a)			x
Shackling ^(a)			x
Drops, curves and inclination of shackle line ^(a)		x	x
Inappropriate shackling ^(a)	x		x
Neck cutting	x		x ^(b)
Incomplete sectioning of carotids	x		x ^(b)
Repeated cuts in conscious birds	x		x ^(b)
Stimulation of wound	x		x ^(b)
Bleeding to death	x		x ^(b)
Prolonged stun-to-neck-cut interval ^(c)	x		x
Birds entering the scalding tank alive	x		x ^(b)

(a): Hazards that have been described in Section 3.6.2 and apply to bleeding during slaughter without stunning (because in the case of bleeding following stunning, they have been included in the relevant stunning method).

(b): Staff and also equipment only in the case of bleeding following stunning, when the hazard/s applies only to a portion of birds (the ineffectively stunned and those recovering consciousness after stunning).

(c): This hazard applies only to bleeding following stunning.

3.7. Response to ToR-2: Criteria to assess performance on animal welfare (including ABMs)

The mandate requests to define ABMs, that can be used to assess welfare performance. In this opinion, welfare performance is addressed by analysing the potential negative welfare consequences occurring to the birds due to the identified hazards. A 'welfare consequence' has been defined as the change in welfare that results from the effect of one or more factors (EFSA AHAW Panel, 2012a). Furthermore, ABMs that can be used to assess qualitatively or quantitatively the welfare consequences were evaluated and a set of ABMs was selected to be included in the outcome tables (Table 8 and Section 3.10).

3.7.1. Welfare consequences

There are several potential (negative) welfare consequences that an animal (bird) can experience due to hazard/s occurring if slaughtering, from arrival at the slaughterhouse to the point where exsanguination is finished, is not carried out correctly. However, due to the complexity of slaughtering and the limited accessibility to animals in some of the phases (e.g. animals in containers at arrival and in lairage, or in the chambers during gas stunning, etc.), not all the welfare consequences can be assessed at the slaughterhouse.

Ten welfare consequences occurring to birds during the processes of slaughtering have been identified: consciousness, heat stress, cold stress, prolonged thirst, prolonged hunger, restriction of movement, pain, fear, distress and respiratory distress. Some of the welfare consequences are specific to the pre-stunning phase (i.e. heat stress, cold stress, prolonged thirst and restriction of movement), others are specific to the stunning phase (consciousness), and others can apply in all phases (pain, fear, distress).

For the welfare consequences identified in Phase 1, several ABMs have been reported to assess the welfare of poultry (Welfare Quality[®], 2009; EFSA AHAW Panel, 2012c); in Phases 2 and 3, for the assessment of the efficacy of the stunning and bleeding processes, qualitative and measurable criteria can be used. EFSA developed a Scientific Opinion on 'the monitoring procedures at slaughter for poultry' (EFSA AHAW Panel, 2013) where ABMs for consciousness have been selected based on their specificity and sensitivity, and have been included in toolboxes specific to the identified scenarios.

3.7.1.1. Description of the welfare consequences, associated ABMs and mitigation measures

The welfare consequences that have been identified as the ones that birds can experience at the time of slaughter are described in this section. The relevant ABMs that are feasible to be assessed in the slaughter context are also listed and will be described in detail in the Section 3.7.2.

The measures that can be used to mitigate the welfare consequences are also reported here. In general, it is the opinion of the experts that the use of 'emergency killing' or of a 'backup stunning method' are practices that must be put in place in every slaughterhouse independently of the corrective actions for hazards proposed in this opinion and reported in the outcome tables (see last column of Tables 9–21).

Thermal stress (heat or cold stress)

Description: This is the inability to maintain a constant body temperature by behavioural and physiological adaptation alone. This can result in heat stress (Lara and Rostagno, 2013) or cold stress (Hunter et al., 2010; EFSA AHAW Panel, 2014).

In extreme or prolonged cases, welfare consequences related to thermal stress (heat stress and cold stress) can lead to multiorgan failure and death, which can be measured by a non-specific ABM, which is DoA (for details see Section 3.7.2). When the temperature is outside the upper level of this thermoneutral zone, birds are 'heat stressed' since they show difficulty achieving a balance between body heat production and body heat loss (DEFRA, 2007). This can occur at all ages and in all types of poultry systems. Petracci et al. (2006) considered that birds can experience heat stress in an environment where temperature and humidity are higher than 25°C and 70%, respectively.

ABMs: The ABMs for heat stress are panting associated with high respiration rate (Grilli et al., 2015) and, in extreme conditions, DoA. Jacobs et al. (2017) showed that panting in ante-mortem inspection is associated with DoA ($p < 0.001$). The potential ABMs for cold stress are shivering, huddling, piloerection and, in extreme conditions, death.

Measures to mitigate thermal stress are based on the correction of the hazards 'too high' or 'too low effective temperature' (see Sections 3.6.1.1 and 3.6.1.2 and Table 9). Furthermore, a reduction in waiting times before unloading containers from the truck will mitigate thermal stress at arrival.

Prolonged hunger

Description: The animal has been unable to get enough food to meet its maintenance requirements for energy, protein or specific nutrients. Prolonged hunger will lead to loss of body weight due to starvation. Although the time of preslaughter feed removal is regulated (Council Directive 2007/43/EC²¹), there is still a risk of feed being removed too early at the farm, transport being delayed or prolonged, or too long waiting time in lairage, resulting in prolonged hunger for the birds. In addition, it must be noted that it is difficult and nearly unfeasible to provide feed to birds at the slaughterhouse.

ABMs: The potential ABMs that are reported for prolonged hunger in poultry are presence of bile, urates or orange casts (sloughed intestinal lining) on the floor of the containers (Savage, 1998); however, it is not always feasible to assess these ABMs when animals are in piled-up containers.

The mitigation measures to alleviate prolonged hunger in birds are, in the first instance, based on actions to correct the hazard (i.e. to provide food and water at arrival/during lairage). Provision of water is important to minimise prolonged hunger because, physiologically speaking, birds need to have water available if they are to continue eating. Alternatively, the waiting time to unloading the containers from the truck should be reduced and the birds slaughtered as soon as possible.

Prolonged thirst

Description: The animal has been unable to get enough water to satisfy its needs, resulting in dehydration.

²¹ Council Directive 2007/43/EC of 28 June 2007 laying down minimum rules for the protection of chickens kept for meat production. OJ L 182, 12.7.2007, p. 19–28.

ABMs: The potential ABM for dehydration is 'dry skin', but this is practically impossible to examine on live poultry in containers and at slaughter, and also not necessarily easy to evaluate post-mortem. A valid ABM is DoA, but this is not specific to prolonged thirst because DoA can have a different or a multi-factorial origin. In the case of 'prolonged thirst', therefore, no ABMs are considered feasible to assess in the context of slaughter.

The mitigation measures to alleviate birds from prolonged thirst are in the first instance based on the corrective actions for the hazard (i.e. to provide water at arrival/during lairage). Alternatively, the waiting time to unloading the containers from the truck should be reduced and the birds slaughtered as soon as possible.

Restriction of movement

Description: While in containers, birds may be over stocked and hence not have the possibility for all to sit at the same time or to change their body position.

ABMs: As it is difficult to assess the body position of all the birds in the containers, the possible ABMs related to bird posture and ease of movement are not perceived as useful. However, overcrowding (no. of animals (or kgs) counted/m²) and piling up have been reported as feasible to be assessed (Chauvin et al., 2011). Instead, resource-based measures (space allowance, container height) can be used.

Mitigation measures: As it is not feasible to provide more space for the birds in the containers, the mitigation measures should be to speed up the process by removing birds from containers as soon as possible and to slaughter the birds as soon as they arrive at the slaughterhouse.

Fear

Description: Birds show exaggerated signs of anxiety such as escape attempts or immobility. Birds might experience fear during unloading of containers, lairage, handling and removing of birds from containers, and during Phases 2 and 3 (stunning and bleeding).

ABMs: It is generally not feasible to assess signs of fear while birds are housed in containers. Even if difficult, however, it is commonly recognised that, in the processes of the pre-stunning phase, 'flight or startling behaviour' and 'vocalisations' are ABMs that can be used to assess fear. In Phases 2 and 3, fear can be assessed also by 'wing flapping' and 'escape attempts'.

Mitigation measures: A mitigation measure used to minimise fear in Phase 1 is blue light (440–490 nm) as it calms birds down and allows them to rest in the lairage zone (see Figure 5) and during handling for shackling. The blue light still allows the workers to see and handle birds with precision, leading to less stress for the animals (Adamczuk et al., 2014). Avila and Abreu (2003) reported that blue light is used for catching birds as it overrides the visual capacity of the birds and they remain still, facilitating the movement of the catcher. In some Brazilian slaughterhouses, blue light is used just before slaughter when the animal is being hung on the shackles. The combination of partially dark ambience with the use of blue light has a calming effect on birds, reducing their excitement (seen as wing flapping) by 56%. Exposure to blue light just before slaughtering shows potential for use in modern slaughterhouses, providing a calming atmosphere and thereby maintaining the breast meat quality (Barbosa et al., 2013).

Although colour has been confused with illuminance in many trials, wavelength has been reported to have an unquestionable effect on poultry production, behaviour and welfare (Lewis and Morris, 2000; Tavares et al., 2015). Light distribution, duration, and intensity have a direct effect on flock performance and welfare (Adamczuk et al., 2014).

In the case of manual restraint, gentle handling of the birds while they are restrained can minimise fear (and pain); the restraining should be done with one hand covering both wings and the other holding both legs and supporting the breast (see Figure 14). Careful selection of people with adequate skills and the right attitude or giving training for them to acquire the skills appropriate to the tasks and species of birds would help to minimise fear in the animals being handled.

Pain

Description: It is an unpleasant sensory and emotional experience associated with actual or potential tissue damage. Most of the processes of slaughtering are painful for conscious animals (see Tables 9–21). For example: in the case of electrical stunning, if birds are shackled while conscious, pain can be expected from shackling to the point of stunning (Jones and Satterlee, 1997; Gentle and Tilston, 2000; Gentle, 2011). Gentle and Tilston (2000) showed that nociceptors are present in the scaly skin over the lateral surface of the legs and that they have response thresholds much lower than the cutaneous forces exerted on this part of the leg during shackling. The maximum discharge rates of these nociceptors occur over a wide range of forces and it appears that a large proportion of the

receptors will be discharging at their maximum rates during shackling. Based on monitoring nociceptors in the legs of poultry in response to quantitative mechanical stimulation, Gentle and Tilston (2000) concluded that shackling is likely to be a very painful procedure.

Pain due to shackling is likely to be worse, due to a cumulative effect in birds that are already suffering from being injured. These injuries might be induced by rough handling during catching, crating and uncrating (Gentle and Tilston, 2000). If waterbath design or electrical settings are suboptimal, this may cause pre-stun shocks or incomplete stunning, which is painful for the birds. A similar situation may occur if gas stunners are not properly calibrated for gas concentration, if birds are exposed to highly aversive gas concentrations, or in relation to gas temperature and humidity.

ABM: Assessing pain in poultry in Phase 1, based on behavioural measures, is not feasible. Pain can be indirectly assessed, however, by scoring injuries. Feasible ABMs are therefore physical damage to bones (e.g. fractures or dislocations), muscles and skin (e.g. scratches and open wounds, bruises). Traumatic injuries during post-mortem inspection have been considered (Grilli et al., 2015) to be an ABM for bad transport, loading/unloading and handling causing negative welfare consequences, with no possibility of distinguishing the phase(s) in which the injuries appeared. Injuries are more visible when birds are removed from the containers.

Possible ABMs for pain when birds are shackled is the duration and forcefulness of 'wing flapping' and 'escape attempts', which can be used to assess the level of pain induced.

ABMs associated with pre-stun shocks or incomplete stunning include 'vigorous wing flapping', 'withdrawal reactions of wings or head' and 'vocalisations'. ABMs associated with pain due to aversive gas exposure during CAS include 'vigorous wing flapping', 'escape attempts' and 'vocalisations'.

During slaughter without stunning, the incision made in the throat to sever blood vessels involves substantial tissue damage in areas well supplied with nociceptors. The activation of the protective nociceptive system induces the animal to experience pain. As the death due to neck-cutting is not immediate, there is a period during which the animal is still conscious and can feel pain.

Mitigation measures: Animals should be handled with care. To minimise pain in the case of shackling, the shackle size should be appropriate for the size of the birds. In addition, the main measure to mitigate pain during slaughtering is to stun and slaughter the birds as soon as possible. This also includes emergency killing: for example, injured birds should not be shackled while conscious and should be immediately killed to avoid additional pain.

During slaughter without stunning, to reduce pain perception, birds should receive a single swift neck cut. For this, the knife must be sharp and sufficiently long to minimise the need for multiple cuts. Implementation of a pre-cut stun (conventional stunning) will eliminate pain associated with robust restraint, neck-cutting and bleeding. Specific training of slaughter personnel and abattoir staff, including management in key areas (such as animal handling, restraint, knife sharpening, animal physiology, signs of stress and pain, times to unconsciousness and signs of loss of consciousness), is vital to ensure good animal welfare (von Holleben et al., 2010).

Distress

Description: This is the state of an animal that has been unable to adapt to stressors and that manifests as abnormal physiological or behavioural responses (Chapter 7.8.1 OIE, 2019). Distress implies an external and usually temporary cause of great physical or mental strain and stress, such as extreme anxiety or fear, inability to cope with environmental conditions, sadness, pain, or the state of being in danger or urgent need.

At slaughter, birds are exposed to a number of distressing situations in a short period of time. However, distress is a welfare status difficult to describe, assess and quantify accurately. The bleeding phase has been identified as the one where mostly, when birds are not properly stunned/not unconscious, they are exposed to different hazards leading to a combination of welfare consequences including distress.

ABMs: no specific ABMs have been identified to assess distress. However, depending on the origin of physical or mental distress, ABMs for other welfare consequences such as pain or fear or thermal stress, can be applied.

Mitigation measures: Post-cut stunning will eliminate distress as well as other welfare consequences that the birds experience when bleeding while conscious.

Respiratory distress

Description: Mental or physiological suffering due to increased CO₂ levels or to lack of O₂ resulting in forced breathing, breathlessness or air hunger.

Respiratory distress can also be induced by the lack of oxygen or hypoxaemia during stunning by inert gas mixtures (Beausolei and Mellor, 2015); however, there is no direct experimental evidence in the literature.

ABMs: In CAS, gasping or intense breathing is shown by all animals. Deep breathing is mostly characterised by an open beak (Gerritzen et al., 2006). Gasping is a form of very deep breathing accompanied by a wide open beak, stretching movements of the neck or bending the neck to backwards (Gerritzen et al., 2006), and is induced by the increased $p\text{CO}_2$ in the blood, which stimulates the breathing centre to wash out CO_2 . Forced breathing (gasping) can therefore also indicate respiratory distress (breathlessness or air hunger). This ABM will start before loss of consciousness and will persist for a certain period of time afterwards. The level and intensity of gasping depends on the CO_2 concentration during the induction phase. Gasping is a sign of respiratory distress and is seen as indicator for breathlessness.

In anoxic situations, the lack of available oxygen (LAPS or exposure to inert gases) can lead to respiratory distress or air hunger. A possible ABM for respiratory distress due to lack of available oxygen is hyperventilation.

Mitigation measures: A certain level of respiratory distress should be accepted as it is inherent to the stunning method. Therefore, no mitigation measures can be implemented.

Consciousness

Description: This is the ability of an animal to feel emotions and being sensible to external stimuli. Consciousness is considered a welfare consequence of ineffective stunning or when animals recover consciousness after stunning.

In fact, failure to induce proper stunning/unconsciousness or recovery of consciousness in birds will lead to birds leaving the stunner conscious or regaining consciousness during the next processes of slaughter. As a result, there is a risk that the birds are neck cut while conscious or that they regain consciousness during the bleeding process.

Despite some exceptions, such as electro-immobilisation or other provoked paralysis, an animal can be presumed to be unconscious when it loses its natural standing position, is not awake and does not show signs of positive or negative emotions such as fear or excitement. Sensitivity of an animal is essentially its ability to feel pain. In general, an animal can be presumed to be insensitive when it does not show any reflexes or reactions to stimuli such as sound, odour, light or physical contact (Council Regulation (EC) No 1099/2009).

If stunning is not correctly carried out or does not produce unconsciousness of sufficient duration such that birds are not fully unconscious during cutting and bleeding, this will evoke pain from the cut and the wound.

ABMs: Signs of consciousness are described in EFSA AHAW Panel (2013), which reports a toolbox for different stunning methods.

The measures to mitigate consciousness are to re-stun with a back-up stunning method, and implementation of post-cut stunning, in the case of slaughter without stunning.

3.7.2. ABMs and their definitions

As mentioned previously, ABMs are used to assess the welfare consequences. They are the responses of an animal to a specific input and can be taken directly from the animal or indirectly by using animal records (e.g. number of animals DoA at the slaughterhouse) (EFSA AHAW Panel, 2012a).

Some ABMs may not be feasible under certain circumstances. For example, birds in the middle of a container may not be visible for assessment, or the fast line speed may make the detection of some ABMs impossible. In this situation, if existence of the hazard is realised, it should be assumed that the related welfare consequences exist.

²² <https://www.ninds.nih.gov/Disorders/Patient-Caregiver-Education/Fact-Sheets/Myoclonus-Fact-Sheet>

Table 8: List of ABMs with relevant definitions and their related welfare consequence/s. References of ABMs are shown in brackets; when references are not available, the definition is based on experts' opinion

ABMs	Definition with References	Relevant welfare consequences
Attempt to regain posture	Head righting (attempt to raise head), head shaking or wing flapping after stunning	Consciousness
Bunching	Clustering together on one part of the available floorspace (see 'huddling')	Fear
Death	Uncontrolled death of birds. Any bird that is found dead in the container or at the spot is considered a mortality or a DoA (Welfare Quality [®] , 2009)	Heat stress, cold stress
Deep breathing	Deep breathing, often with open beak, can be accompanied by stretching the neck (gaspings) (Gerritzen et al., 2006)	Respiratory distress
Escape attempts	Attempts to move, run or fly away from the situation (Graml et al., 2007)	Fear, pain
Flight	Moving, running or flying away or attempts to do so, often accompanied by vocalisations (see 'escape attempts')	Fear
Head shaking ^(a)	Rapid shaking of the head, most times accompanied by stretching and/or withdrawal movements of the head (Gerritzen et al., 2006)	Pain, fear and/or respiratory distress
Huddling	Sitting close together in tight groups or clumps often with open space in between (Welfare Quality [®] , 2009)	Cold stress
Hyperventilation	Excessive rate and depth of breathings (https://edis.ifas.ufl.edu/vm019 , Butcher and Miles, 2018)	Respiratory distress
Injuries	Tissue damage (bruises, scratches, broken bones, dislocations) (EFSA AHAW Panel, 2012c)	Pain
Maintenance of posture	Birds in sitting or standing position capable of keeping their heads lifted and birds regaining posture after loss of balance (Gerritzen et al., 2004; Benson et al., 2012)	Consciousness
Muscle jerks	Muscle contractions similar to spasms, tremors and pedalling movements of the legs ²²	Pain
Overcrowding	When the space allowance is insufficient for birds to sit all at the same time without overlapping. It is measurable by counting the birds per m ² .	Restriction of movement, heat stress
Panting	Breathing with short, quick breaths with an open beak (Welfare Quality [®] , 2009)	Heat stress
Piling up	Birds crowding against and on top of each other	Restriction of movement
Piloerection	Erection or ruffling or bristling of feathers (Strawford et al., 2011)	Cold stress
Presence of bile	Greenish bile or bile salt on the floor of the containers	Prolonged hunger
Presence of urates or orange cast on the floor of containers	Crystallised urates on the floor of the container	Prolonged hunger
Shivering	Shaking slightly and uncontrollably (Strawford et al., 2011)	Cold stress
Vocalisation	Single or repeated short and loud shrieking (screaming) at high frequencies (Manteuffel et al., 2004)	Fear, pain
Wing flapping ^(b)	A prolonged bout of continuous, rapid wing-flapping (McKeegan et al., 2007a; McKeegan et al., 2007b)	Fear
Withdrawal reaction	Fast avoiding movement of the stimulated part of the body (i.e. neck, head, wing, or leg; Erasmus et al., 2009)	Pain

(a): Due to exposure to gas mixture.

(b): Wing flapping should not be confused with tonic/clonic movements due to electrical stunning.

During the process of handling, the effects of transportation conditions and of previous processes can be measured by counting the number of dead birds on arrival.

In fact, a specific measure of the effects of the pre-stunning phase is DoA, which is the last consequence of extremely poor welfare and is considered by many authors (Haslam et al., 2008; Chauvin et al., 2011; Grilli et al., 2015) as an ABM linked, for example, with thermal stress (Jacobs, 2016). However, the DoA rate is calculated when the birds are handled for restraining and is the consequence of all the pre-stunning processes that have already occurred with no possibility of distinguishing the effects of any one process. Risk factors for high DoA in broiler chicken in the pre-stunning phases have been identified as: space allowance in containers (Nijdam, 2004; Oba et al., 2009); climatic conditions (Nijdam, 2004; Jacobs, 2017; Haslam et al., 2008; Chauvin et al., 2011), and lairage time (Nijdam et al., 2005; Oba et al., 2009; Chauvin et al., 2011).

The welfare consequences can depend on several hazards, e.g. bad climatic conditions (too hot, too cold, rainy, windy). Chauvin et al. (2011) found that rain and wind at lairage are risk factors (Odds Ratio (OR) = 1.34, 95% CI 1.09–1.64) of DoA increase. The effects of the hazards and the severity of the welfare consequences are impacted by the duration of the process. Chauvin et al. (2011) showed that a lairage time of more than 260 min (compared with 160–260 min) is a risk factor for DoA (OR = 1.2; $p = 0.05$). Similar results were demonstrated by Nijdam et al. (2004) with an OR = 1.03 for each additional 15 min spent in lairage. The risk of increased mortality during lairage is of course also linked to other factors, such as bird age.

Interestingly, Nijdam et al. (2004) quantified the impact of the space allowance on DoA with OR = 1.09 for each additional bird in a compartment. A decrease of the number of birds in a compartment should therefore prevent the risk for increased DoA (Chauvin et al., 2011), which is the latest stage of compromised welfare.

3.8. Response to ToR-3: identification of preventive and corrective measures

The hazards that potentially appear during slaughtering can be prevented or corrected by implementing structural or managerial actions. Preventive and corrective measures refer to the actions that can be taken to avoid or stop the hazard. In cases where there is no possible correction for certain hazards, measures to mitigate welfare consequences linked to these hazards have been described in the text of the opinion (see Section 3.7.1).

In general, according to the mandate, preventive and corrective measures can be grouped into two broad categories:

- Structural measures mean infrastructure or equipment required to minimise or eliminate the occurrence of hazards or to minimise suffering in birds.
- Management measures mean decisions to be made or resources to be put in place by personnel with responsibility or legal obligation for animal welfare.

Based on experts' knowledge and consideration of the available literature, relevant preventive and corrective measures for each phase of slaughtering and each identified hazard have been listed in the outcome tables (for details, see Section 3.10, Tables 9–21).

In addition, specific preventive and corrective measures have been developed in association with the relevant hazard description in Section 3.6.

Preventive measures that apply to more than one hazard (e.g. staff training) are described in Section 3.8.1 below, whereas corrective measures, when available, are specific for each hazard (and described in Section 3.6).

In the case of corrective measures, only those that are considered feasible to implement in a slaughterhouse have been reported. It has to be noted that, because slaughtering of birds is a continuous process, the corrective measures feasible to be put in place subsequently become preventive measures for the birds coming into the slaughter line.

3.8.1. Preventive measures that apply to multiple hazards²³

3.8.1.1. Staff training

Description: Training of staff to acquire the knowledge and skills required to perform their allocated tasks efficiently, letting them know that animals are sentient beings that can suffer pain and fear and therefore should be treated correctly to avoid negative welfare consequences. Staff training has been

²³ See Tables 9–21.

identified as a preventive measure for hazards in all the process assessed (see Tables 9–21) This shows that even in a well-designed and equipped slaughter plant, training of staff is key to ensuring the protection of animals (HSA, 2015; European Commission, 2017b, 2018b).

3.8.1.2. Staff rotation

Description: Staff rotation is a management policy in which employees are moved between two or more tasks to avoid boredom and fatigue. Staff fatigue is considered one of the most important factors that can lead to increase a worker's hazards exposure during slaughter; it can reduce mental and physical functioning, impair judgement and concentration, lower motivation, slow reaction times and increase risk-taking behaviour (Safe Work Australia, 2013).

Staff handling and shackling of live birds should be rotated to other duties at regular intervals to safeguard bird welfare (HSA, 2015).

Staff rotation has been identified as an important preventive measure during live bird shackling for electrical stunning methods and slaughter without stunning, as well as a measure to avoid incorrect application of mechanical stunning methods and slaughter without stunning.

3.8.1.3. Scheduling slaughter of birds/prioritising slaughter

Description: This consists of planning and coordination of arrival of live birds, unloading, lairage and slaughter, including communication with farms, live bird catching teams and hauliers (HSA, 2015; European Commission, 2017b, 2018b). This would also apply to all three phases of slaughtering.

Effective coordination should minimise waiting time upon arrival of live birds and keep lairage duration to the minimum (European Commission, 2017b, 2018b). Scheduling should also include contingency plans to prioritise the slaughter of birds on occasions when holding them in lairage any longer would lead them to experience negative welfare consequences.

3.8.1.4. Appropriate design and maintenance of facilities and equipment

Description: Design, construction and routine maintenance of slaughterhouse facilities and equipment is important to ensure good welfare. This would apply to all the equipment used in the slaughterhouse (European Commission, 2017b, 2018b). Birds delivered in containers should be handled with care during unloading and movement within slaughterhouses. Uneven floors and faulty or poorly maintained equipment (such as the forklifts used in the movement of containers) could lead to tipping or tilting of containers, with serious welfare consequences.

3.8.1.5. Routine inspection

Description: Routine inspection of containers is an important practice to identify faulty ones and to ensure they are repaired/replaced to avoid causing poor welfare. Containers with sharp projections or protrusions will cause injuries and death in severe cases. Staff responsible for removal of birds from the containers or those operating container washing system should be trained to identify defects and report them to managers.

3.8.1.6. Report to managers

Description: Slaughterhouse staff should be encouraged to report any hazards to managers, especially broken or defective containers that may cause injuries in live birds (HSA, 2015).

Additionally, there should be written procedures for all slaughter processes, and staff should report any deviations to managers.

3.8.1.7. Proper machine construction

Description: Machines used for unloading and movement of containers should be well constructed and maintained to avoid poor welfare due to loud noise or emissions (HSA, 2015; European Commission, 2017b, 2018b).

3.8.1.8. Slow down line speed

Description: Faster line speeds (throughput rates) are not always conducive to maintaining good welfare, especially during shackling. For example, each person shackling live birds in poultry slaughterhouses is expected to shackle one thousand birds per hour (about 17 birds per minute); therefore, a slaughterhouse killing ten thousand birds per hour would engage ten people for shackling live birds. In the current industrial situation, such a physically demanding task would inevitably lead to poor welfare consequences for birds (due for example, to rough handling or inappropriate shackling).

and staff if the latter were inexperienced or and/or fatigued. One way to prevent this hazard is to slow down line speed.

3.8.1.9. Correct design and setting up of equipment

Description: Tipping live birds from containers on to conveyors is practiced worldwide and involves careful setting up of equipment (HSA, 2015; European Commission, 2017b, 2018b). In this procedure, containers full of birds are tilted such that the birds in different compartments of a modular system gently slide down onto the conveyor. To achieve this, slides of different lengths are constructed and positioned so as to distribute live birds evenly on the reception conveyor, which then drops birds onto another conveyor positioned at right angles that carries them to the gas stunning equipment or to the shackling point in water-bath-stunning systems. The rate of emptying of containers and the synchronisation of these conveyors are vital in preventing bunching of birds leading to poor welfare outcomes.

3.8.1.10. Redesign shackle line

Description: Lines conveying live birds from the shackling point to the entrance to water-bath stunners should operate smoothly, without drops, curves or inclination, as these are known to trigger wing flapping and struggling. Any sudden drop can cause vibration (vertical jolts), and curves can cause birds to swing; both can have welfare consequences (EFSA, 2004).

3.8.1.11. Reduce throughput rate

Description: Slaughterhouse design and construction should take into account the expected throughput rates, and the water-bath stunner should be of sufficient length to achieve effective stunning. Increasing the line speed with no other process changes would lead to shorter exposures to electrical water-bath stunning, with severe welfare consequences. In this situation, reducing throughput rate is probably the only preventive measure that can be implemented.

3.8.1.12. Regular calibration and maintenance of the equipment (electrical stunners)

Description: Electrical stunners, especially water-bath systems, should display the output voltage and, ideally, the total amount of current under load. For these displays to be accurate, the stunners should be regularly calibrated and maintained according to the manufacturer's instructions (HSA, 2015; AVMA, 2016; European Commission, 2017b, 2018b). Failing to do so means birds will experience inappropriate electrical parameters with severe welfare consequences due to ineffective stunning or recovery of consciousness.

3.8.1.13. Adjust equipment according to what is required

Description: Electrical parameters used for head-only or water-bath stunning should lead to effective stunning. The outcomes should be routinely monitored and electrical stunning voltage/current output adjusted if necessary (HSA, 2017a,b).

3.8.1.14. Monitor stun quality routinely

Description: The effectiveness of stunning should be routinely monitored to protect the birds' welfare (HSA, 2015; AVMA, 2016; European Commission, 2017b, 2018b). In this regard, a previous opinion published by EFSA AHAW Panel (2013) provides guidance to key stages of monitoring and indicators of consciousness/unconsciousness.

3.8.1.15. Proper monitoring of gas equipment

Description: Proper monitoring and maintenance of gas concentration is vital to ensure good welfare at slaughter. Gas stunning is becoming increasingly popular on animal welfare grounds. Gas concentration(s) in the equipment should be continuously monitored and the oxygen or carbon dioxide monitors should be routinely calibrated to ensure they read and display accurately (HSA, 2015; AVMA, 2016; European Commission, 2017b, 2018b).

3.8.1.16. Use of equipment is fit for the purpose

Description: Adaptations to stunning equipment (e.g., in the case of a captive bolt gun, the associated bolt parameters of diameter, penetration depth, and velocity) must be appropriate for the species and size of birds to ensure they are immediately rendered unconscious (HSA, 2017a,b). This is valid for all the methods that require the use of equipment.

For example, the compressed air line pressure or the power of the cartridge or spring should be appropriate for the species and size of birds. Cartridges should be stored in a dry place according to the manufacturer's instructions. Operator fatigue and overheating of the gun due to repeated firings in quick succession would lead to poor welfare consequences. There should be sufficient guns such that they can be allowed to cool between operations, and they should be cleaned and maintained according to manufacturer's instructions. Similarly, lack of complete severance of brain and spinal cord and/or blood vessels in the neck following mechanical cervical dislocation would lead to poor welfare consequences.

3.8.1.17. No preventive measures

Description: This means that the only option to prevent the hazard is to change the method or to try to reduce the consequences of the hazard on the welfare of the birds (see measures to mitigate welfare consequences, Section 3.7.1).

3.9. Response to ToR-4: Specific hazards for animal categories

The European Commission mandate requests the identification of specific hazards related to species or types of animals. The present opinion describes slaughtering methods to be used for adult birds intended for human consumption (see identification of hazards in Sections 3.6.1–3.6.3); however, some specificities have been pointed out because of the possible negative welfare implications, such as:

- Heavy animals (e.g. turkeys, geese and breeders from other species such as *Gallus* or ducks) can suffer more from being shackled conscious than lighter animals.
- Some animal species, such as duck and geese, can have more resistance to electrical current due to their feathering; attention therefore has to be paid to decreasing resistance (e.g. watering) and using an appropriate current to render animals unconscious.
- Swan necking in ducks and geese to physically avoid the waterbath: when ducks and geese are hung on shackle lines they bend their necks backward such that they remain parallel to the back, and they maintain this posture in the waterbath stunner. By adopting this posture, the base of the neck or crop region is immersed while the head may remain above the water. In this situation, it is doubtful that the applied current flows through the brain unless the water bath is set to facilitate deeper immersion of birds (HSA, 2015).
- Laying hens with the fragile bones due to osteoporosis: osteoporosis is a decrease in the amount of fully mineralised structural bones, leading to increased susceptibility to fracture; it has been identified as the main factor causing bone fragility in hens (Whitehead, 2004). Gregory and Wilkins (1989) reported the results of a survey of end-of-lay hens from battery cages in the UK in which 29% of hens had one or more broken bones.
- Flighty birds should not be shackled because they are too nervous and show wing flapping and attempts to escape. This is the case, for example, with game birds such as guinea fowl, pheasant and partridge that, when hung on the shackle line, will attempt to escape/fly, leading to dislocated or broken wings.

3.10. Content of outcome tables linking the elements requested by the ToRs

Outcome tables were developed to include summarised information linking all the elements analysed to respond to the ToRs of this opinion – i.e. hazards, welfare consequences, relevant ABMs, origin of hazards, preventive and corrective actions. The outcome tables are intended as the main result of this scientific opinion, providing a concise presentation of all retrieved information. Detailed supporting background information is included in the previous sections of the Assessment.

In this opinion, outcome tables have been grouped by phase (see following sections).

3.10.1. Outcome tables related to the processes grouped in Phase 1 – pre-stunning

This phase includes the following processes: arrival, unloading of the containers from the truck, lairage, and handling and removing of birds from the containers. For each process, information on hazards, welfare consequences and relevant ABMs and corrective measures; hazard's origin and preventive measures can be retrieved from Tables 9–12.

Table 9: Outcome table on 'arrival': hazards (with the number of the section where the hazard's full description is provided) with relevant welfare consequences, ABMs, origin of hazards, and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Too high effective temperature (3.6.1.1)	Heat stress	Staff, equipment, facilities	Lack of skilled operators, environment, not enough ventilation in the truck, prolonged waiting time	<ul style="list-style-type: none"> • Staff training • Increase space allowance • Avoid hottest hours of the day for transport • Unload immediately following the arrival • Provide adequate ventilation to the truck at arrival place • Misting or nebulisation assuring appropriate ventilation • Protect from adverse weather conditions 	Provide adequate ventilation
Too low effective temperature (3.6.1.2)	Cold stress	Staff, equipment, facilities	Lack of skilled operators, environment, no protection (e.g. absence of curtains in the truck, no heating system, etc.), prolonged waiting time	<ul style="list-style-type: none"> • Staff training • Before departure, provide curtains and other protection and close the ventilation • Avoid coldest hours of the day for transport • Unload immediately following the arrival • Provide adequate shelter to the truck at arrival place 	Provide curtains or other protection when the birds are on the truck; unload and bring the birds to a thermal neutral zone (with heaters)
Insufficient space allowance (3.6.1.3)	Restriction of movements, heat stress	Staff	Lack of skilled operators, too many animals are put in the containers	<ul style="list-style-type: none"> • Staff training • Adjust the number of birds to size of the containers 	None
Food deprivation too long (3.6.1.4)	Prolonged hunger	Staff	Lack of skilled operators, feeders removed too early on-farm, prolonged transport and/or prolonged waiting time	<ul style="list-style-type: none"> • Staff training • Planning of feed withdrawal on-farm according to duration of transportation and waiting time prior to slaughter • Scheduling slaughter of animals • Prioritising slaughter 	Provide food and water to the birds

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Water deprivation too long (3.6.1.5)	Prolonged thirst	Staff	Lack of skilled operators, drinkers removed too early on-farm, prolonged transport and/or prolonged waiting time	<ul style="list-style-type: none"> • Staff training • Birds should have access to water till catching and loading in containers 	Provide water to the birds
ABMs: panting, death, shivering, huddling, piloerection, overcrowding, piling up, presence of bile, urates or orange cast on the floor of containers (no feasible ABMs for prolonged thirst)					

ABM: animal-based measure; SOP: standard operating procedure.

Table 10: Outcome table on 'unloading of containers from the truck': hazards (with the number of the section where the hazard's full description is provided), with relevant welfare consequences, ABMs, origin of hazards, and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Rough handling of containers (3.6.1.6)	Pain, fear	Staff, facilities	Lack of skilled operators, improper handling of containers, careless driving of forklifts, uneven floor	<ul style="list-style-type: none"> • Training of staff in proper handling • Appropriate design and maintenance of facilities and equipment 	None
Jamming or crushing of heads, wings and legs in containers (3.6.1.7)	Pain, fear	Staff, equipment	Lack of skilled operators, use of damaged containers	<ul style="list-style-type: none"> • Staff should be trained to routinely inspect containers • Remove broken containers or report to managers 	None
ABMs: injuries, vocalisation					

ABM: animal-based measure; SOP: standard operating procedure.

Table 11: Outcome table on 'lairage': hazards (with the number of the section where the hazard's full description is provided), with relevant welfare consequences, ABMs, origin of hazards, and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Too high effective temperature (3.6.1.1)	Heat stress	Staff, equipment, facilities	Environment; not enough ventilation in the lairage area, prolonged waiting time	<ul style="list-style-type: none"> • Staff training • Increase space allowance • Unload immediately following the arrival • Provide adequate ventilation in lairage area • Misting or nebulisation assuring appropriate ventilation • Increase the space between the containers in lairage • Protect from adverse weather conditions 	Provide adequate ventilation
Too low effective temperature (3.6.1.2)	Cold stress	Staff, equipment, facilities	Environment; no protection (e.g. absence of curtains in the truck/lairage area, no heating system, etc.), prolonged waiting time	<ul style="list-style-type: none"> • Staff training • Provide adequate shelter and heating in lairage • Unload immediately following the arrival 	Bring the birds to a thermal neutral zone (with heaters)
Food deprivation too long (3.6.1.4)	Prolonged hunger	Staff	Feeders removed too early on-farm, prolonged transport and/or prolonged waiting time	<ul style="list-style-type: none"> • Staff training • Planning of feed withdrawal according to waiting time prior to slaughter • Scheduling slaughter of animals • Prioritising slaughter 	Provide food and water to the birds.
Water deprivation too long (3.6.1.5)	Prolonged thirst	Staff	Drinkers removed too early on farm, prolonged transport and/or prolonged waiting time	<ul style="list-style-type: none"> • Staff training • Birds should have access to water till catching and loading in containers 	Provide water
Unexpected loud noise (3.6.1.8)	Fear	Staff, equipment, facilities	Staff shouting, machine noise, poor design and layout of the facilities	<ul style="list-style-type: none"> • Identify and eliminate the source of noise • Staff training • Avoid personnel shouting 	None
Insufficient space allowance (3.6.1.3)	Restriction of movement, heat stress	Staff	Too many animals are put in the containers	<ul style="list-style-type: none"> • Staff training • Adjust the number of birds to size of the containers 	None

ABMs: panting, death, shivering, huddling, piloerection, overcrowding, piling up, presence of bile, urates or orange cast on the floor of containers, flight or startling behaviour, vocalisations (no feasible ABMs for prolonged thirst)

ABM: animal-based measure; SOP: standard operating procedure.

Table 12: Outcome table on 'handling and removing of birds from crates or containers': hazards (with the number of the section where the hazard's full description is provided), with relevant welfare consequences, ABMs, origin of hazards, and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Rough handling of the birds during removal from the containers (3.6.1.9)	Pain, fear	Staff, facilities, equipment	Unskilled personnel; operator fatigue; high throughput rate, poorly designed containers (with small openings)	<ul style="list-style-type: none"> • Staff training • Staff rotation • Change container system • Slow down the line speed 	None
Tipping or dumping on conveyors (3.6.1.10)	Pain, fear	Staff, equipment	Poor handling; equipment poorly designed and constructed; speed of tilting birds; slow speed of reception belt	<ul style="list-style-type: none"> • Staff training • Staff rotation • Correct design and setting up of equipment 	Distribute birds evenly on the belt
Bunching on the conveyor belts (3.6.1.11)	Pain, fear	Equipment	Slow moving conveyor/fast transfer between conveyors	Correct design and setting up of the conveyor belt	Synchronise speed of the conveyor belt

ABMs: injuries, vocalisations, wing flapping, bunching

ABM: animal-based measure; SOP: standard operating procedure.

3.10.2. Outcome tables related to the processes grouped in Phase 2 – stunning

This phase includes the following processes: electrical, controlled atmospheres, mechanical methods (waterbath, head-only, gas methods, LAPS, captive bolt, percussive blow and cervical dislocation) and relevant restraint, if required by the method. For each method, information on hazards, welfare consequences and relevant ABMs and corrective measures; hazard's origin and preventive measures can be retrieved from Tables 13–19.

Table 13: Outcome table on 'electrical waterbath stunning': hazards (with the number of the section where the hazard's full description is provided), with relevant welfare consequences, ABMs, origin of hazards, and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Inversion (3.6.2.2)	Pain, fear	Equipment	Shackling	None	None
Shackling (3.6.2.3)	Pain, fear	Equipment	Shackling is part of the method	None	None
Inappropriate shackling (3.6.2.4)	Pain, fear	Staff, equipment	Lack of skilled operators, operator fatigue, rough handling during catching, crating and uncrating, fast line speed, size and design of the shackle inappropriate for the bird size, force applied during shackling	<ul style="list-style-type: none"> • Staff training • Staff rotation • Appropriate number of people shackling to match the line speed • Shackle carefully • Size and design of shackle appropriate for bird sizes • Stun the birds before shackling • Kill injured birds before shackling 	Shackle correctly
Drops, curves and inclination of shackle line (3.6.2.5)	Pain, fear	Equipment, facility	Poor design, layout and construction of shackle line	Redesign shackle line to avoid these hazards	None
Pre-stun shocks (3.6.2.6)	Pain, fear	Staff, equipment	Rough handling of birds during shackling, shackling of birds with broken or dislocated wings; absence of breast comfort plates, inappropriate shackle size, inappropriate positioning of the waterbath in relation to the shackle line and/or bird size, wing flapping at the entrance to the water bath, overflow of electrified water at the entrance to the waterbath, lack of an electrically isolated entry ramp	<ul style="list-style-type: none"> • Staff training • Gentle shackling of birds • No shackling of birds with broken or dislocated wings • Use breast comfort plates and other measures to minimize wing flapping • Use appropriate shackle size • Position the waterbath according to the size and species • Avoid overflow of the water at the entrance • Implement measures such as electrically isolated entry ramp to prevent wings making contact with water prior to immersion of the head 	None

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Poor electrical contact (3.6.2.7)	Consciousness, pain, fear	Staff, equipment	Inappropriate shackling practices (e.g. shackling of small/underweight birds, shackling by one leg); poor or intermittent contact between shackles and earth bar due to incorrect positioning and dirtiness; shackles inappropriate for the size of the birds; dirty and dry shackles	<ul style="list-style-type: none"> • Staff training • Position the earth bar correctly and clean it regularly to maintain good electrical contact with the shackle • Use shackles appropriate for the size of birds • Clean the shackles using proper detergents • Wet shackles before hanging birds 	None
Too short exposure time (3.6.2.8)	Consciousness, pain, fear	Staff	Lack of skilled operators, high throughput rate in a multiple birds waterbath stunning	<ul style="list-style-type: none"> • Staff training • Reduce throughput rate to one appropriate for the electrical stunning parameters 	None
Inappropriate electrical parameters (3.6.2.9)	Consciousness, pain, fear	Staff, equipment	Wrong choice of electrical parameters or equipment; poor or lack of calibration; voltage/current applied is too low; frequency applied is too high for the amount of current delivered; lack of skilled operators; lack of monitoring of stun quality; lack of adjustment of the settings to meet the requirements	<ul style="list-style-type: none"> • Use parameters appropriate for the current frequency and waveforms • Ensure the voltage is sufficient to deliver minimum current to each bird in the waterbath • Regular calibration and maintenance of the equipment • Staff training • Monitor stun quality routinely and adjust the equipment accordingly 	None
Inability to deliver minimum current to all the birds (3.6.2.10)	Consciousness, pain, fear	Equipment	Method incapable of coping with biological variations among birds	<ul style="list-style-type: none"> • Group birds to be as homogeneous as possible • Set electrical parameters that allow each bird to receive minimum current required • Change the method 	None

ABMs: signs of consciousness, injuries, attempt to regain posture, wing-flapping, vocalisations, muscle jerks, escape attempts

ABM: animal-based measure; SOP: standard operating procedure.

Table 14: Outcome table on 'head-only electrical stunning': hazards (with the number of the section where the hazard's full description is provided), with relevant welfare consequences, ABMs, origin of hazards, and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Manual restraint (3.6.2.1)	Pain, fear	Staff	Presentation of birds to the method is required	None	None
Inversion (3.6.2.2)	Pain, fear	Equipment	Shackling or restraint in a cone	Avoid inversion of conscious animals	None
Shackling (3.6.2.3)	Pain, fear	Equipment	Depending on the choice of slaughterhouse, shackling may be part of the method	Avoid shackling conscious animals	None
Drops, curves and inclination of shackle line (3.6.2.5)	Pain, fear	Equipment, facility	Poor design, layout and construction of shackle line	Redesign shackle line to avoid these hazards	None
Inappropriate shackling (3.6.2.4)	Pain, fear	Staff, equipment	Lack of skilled operators, operator fatigue, rough handling during catching, crating and uncrating, fast line speed, size and design of the shackle inappropriate to the bird size, force applied during shackling	<ul style="list-style-type: none"> • Staff training • Staff rotation • Appropriate number of people shackling to match the line speed • Shackle carefully • Size and design of shackle appropriate for birds' size • Stun the birds before shackling • Kill injured birds before shackling 	Shackle correctly
Poor electrical contact (3.6.2.7)	Consciousness, pain, fear	Staff, equipment	Lack of skilled operators; staff fatigue; incorrect placement of the electrodes; poorly designed and maintained equipment; intermittent contact	<ul style="list-style-type: none"> • Staff training • Staff rotation • Ensure correct presentation of the birds • Ensure correct maintenance of the equipment • Ensure the equipment includes electrodes for different sized animals • Ensure continuous contact between the electrodes and the birds • Ensure regular calibration of the equipment 	None

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Too short exposure time (3.6.2.8)	Consciousness, pain, fear	Staff	Lack of skilled operators, high throughput rate.	<ul style="list-style-type: none"> • Staff training • Reduce throughput rate • Ensure a timer is built in the stunner to monitor the time of exposure or use a visual or auditory warning system to alert the operator 	None
Inappropriate electrical parameters (3.6.2.9)	Consciousness, pain, fear	Staff, equipment	Wrong choice of electrical parameters or equipment; poor or lack of calibration; voltage/current applied is too low; frequency applied is too high for the amount of current delivered; lack of skilled operators; lack of monitoring of stun quality; lack of adjustments to the settings to meet the requirements	<ul style="list-style-type: none"> • Use parameters appropriate for the current frequency and waveform • Ensure the voltage is sufficient to deliver minimum current • Regular calibration and maintenance of the equipment • Staff training • Consider the factors contributing to high electrical resistance and minimise or eliminate the source of high resistance • Monitor stun quality routinely and adjust the equipment accordingly • Use constant current source equipment • Wetting the head of the bird with a damp sponge 	None

ABMs: signs of consciousness, injuries, wing flapping, vocalisations, attempt to regain posture, escape attempts

ABM: animal-based measure; SOP: standard operating procedure.

Table 15: Outcome table on 'gas stunning': hazards (with the number of the section where the hazard's full description is provided), with relevant welfare consequences, ABMs, origin of hazards, and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Exposure to too high CO₂ concentration (3.6.2.11)	Pain, fear, (respiratory) distress	Staff, equipment	Lack of skilled operators, lack/poor calibration of monitors, poor administration of gas during injection.	<ul style="list-style-type: none"> • Staff training • Proper monitoring and maintenance of gas concentration • Maintenance and calibration of the equipment 	Adjust gas concentration
Too short exposure time (3.6.2.8)	Consciousness, (respiratory) distress	Staff, equipment	Lack of skilled operators, lack of monitoring, line speed too high for the capacity of the slaughterhouse	<ul style="list-style-type: none"> • Staff training • Maintain adequate exposure time 	Increase the exposure time until induction of unconsciousness
Too low concentration of gas (3.6.2.12)	Consciousness, (respiratory) distress	Staff, equipment	Lack of skilled operators, lack of gas monitoring, property of the gas, concentration of the gas, uneven distribution of the gas, method of injection.	<ul style="list-style-type: none"> • Staff training • Adequate gas monitoring and maintenance of required concentration • Maintain adequate exposure time for the gas concentration • Maintenance and calibration of the equipment 	Adjust gas concentration until induction of unconsciousness

ABMs: signs of consciousness, wing flapping, escape attempts, head shacking, deep breathing

ABM: animal-based measure; SOP: standard operating procedure.

Table 16: Outcome table on 'low atmospheric pressure stunning (LAPS)': hazards (with the number of the section where the hazard's full description is provided), relevant welfare consequences, ABMs, origin of hazards, and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Too fast decompression (3.6.2.13)	Pain, respiratory distress	Staff, equipment	Lack of skilled operators, wrong rate of decompression	<ul style="list-style-type: none"> • Staff training • Use correct rate of decompression 	None
Expansion of gases in the body cavity (3.6.2.14)	Pain	Equipment	Part of the method	None	None

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Too short exposure time (3.6.2.8)	Consciousness, respiratory distress	Staff, equipment	Lack of skilled operators, too short duration of exposure considering the rate of decompression	<ul style="list-style-type: none"> • Staff training • Maintain adequate duration and decompression rate 	None

ABMs: signs of consciousness, escape attempts, wing flapping, hyperventilation

ABM: animal-based measure; SOP: standard operating procedure.

Table 17: Outcome table on 'captive bolt stunning': hazards (with the number of the section where the hazard's full description is provided), relevant welfare consequences, ABMs, origin of hazards, and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Manual restraint (3.6.2.1)	Pain, fear	Staff	Presentation of birds to the method is required	None	None
Inversion (3.6.2.2)	Pain, fear	Equipment	Shackling or restraint in a cone	Avoid inversion of conscious animals	None
Incorrect shooting position (3.6.2.15)	Consciousness, pain, fear	Staff	Lack of skilled operators, operator fatigue, poor presentation of birds	<ul style="list-style-type: none"> • Staff training and rotation • Appropriate restraint 	Stun in the correct position
Incorrect captive bolt parameters (3.6.2.16)	Consciousness, pain, fear	Staff, equipment	Lack of skilled operators, wrong choice of equipment, poor maintenance of the equipment, too narrow bolt diameter, shallow penetration, low bolt velocity	<ul style="list-style-type: none"> • Staff training • Use equipment fit for the purpose 	None

ABMs: signs of consciousness, injuries, wing flapping, vocalisations, attempt to regain posture

ABM: animal-based measure; SOP: standard operating procedure.

Table 18: Outcome table on 'percussive blow': hazards (with the number of the section where the hazard's full description is provided), relevant welfare consequences, ABMs, origin of hazards, and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Manual restraint (3.6.2.1)	Pain, fear	Staff	Presentation of birds to the method is required	None	None
Inversion (3.6.2.2)	Pain, fear	Equipment	Shackling or restraint in a cone	Avoid inversion of conscious animals	None
Incorrect application (3.6.2.17)	Consciousness, pain, fear	Staff	Lack of skilled operators, operator fatigue, poor restraint, hitting in wrong place, insufficient force delivered to the head	Staff training and rotation	Correct application of the method: place the head of the bird on a hard surface while delivering the blow

ABMs: signs of consciousness, injuries (pain), vocalisations, wing flapping, attempt to regain posture

ABM: animal-based measure; SOP: standard operating procedure.

Table 19: Outcome table on 'cervical dislocation': hazards (with the number of the section where the hazard's full description is provided), relevant welfare consequences, ABMs, origin of hazards, and preventive and corrective measures

Hazard	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Manual restraint (3.6.2.1)	Pain, fear	Staff	Presentation of birds to the method is required	None	None
Inversion (3.6.2.2)	Pain, fear	Equipment	Shackling or restraint in a cone	Avoid inversion of conscious animals	None
Incorrect application (3.6.2.17)	Consciousness, pain, fear	Staff, equipment	Lack of skilled operators, operator fatigue, equipment not suitable for size/species of birds, attempt to induce cervical dislocation by crushing of the neck rather than by stretching and twisting	<ul style="list-style-type: none"> Staff training and rotation Use of equipment fit for purpose 	Correct application of the method: use cervical dislocation by stretching and twisting

ABMs: signs of consciousness, injuries (pain), vocalisations, wing flapping, attempt to regain posture

ABM: animal-based measure; SOP: standard operating procedure.

*: Manual in birds up to 3 kg and mechanical in birds weighing from 3 to 5 kg.

3.10.3. Outcome tables related to the processes grouped in Phase 3 – bleeding

This phase includes the following processes: bleeding following stunning and bleeding during slaughter without stunning, with relevant restraint. For each process, information on hazards, welfare consequences and relevant ABMs and corrective measures; hazard's origin and preventive measures can be retrieved in Tables 20 and 21, respectively.

Table 20: Outcome table on 'bleeding following stunning': hazards (with the number of the section where the hazard's full description is provided), relevant welfare consequences, ABMs, origin of hazards, and preventive and corrective measures

Hazard*	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Prolonged stun-to-neck-cut interval (3.6.3.1)	Consciousness, pain, fear	Staff, equipment (depending on the stunning method)	Lack of skilled operators, too long time between stunner and neck-cutter	<ul style="list-style-type: none"> • Staff training • Prompt and accurate neck cutting • Ensuring back-up neck-cutting • Reduce stun-to neck cutting interval 	None
Incomplete sectioning of carotids (3.6.3.2)	Consciousness, pain, fear	Staff, equipment (depending on the neck-cutter)	Lack of skilled operators, blunt knife, performance of the automatic neck-cutting device, failure to cut both carotid arteries	<ul style="list-style-type: none"> • Training of staff • Use sharp knife • Setting-up of the automatic neck-cutting device • Ensure both carotid arteries cut 	Completely cut both arteries
Neck cutting (3.6.3.3)	Pain	Staff, equipment	Lack of skilled operators, ineffective stun or recovering of consciousness before neck cutting	<ul style="list-style-type: none"> • Apply proper stunning and proper stun-to-stick interval • Train the staff to monitor consciousness and use backup method before neck cutting 	None
Repeated cuts (3.6.3.4)	Pain	Staff, equipment (failure in automatic cut)	Lack of skilled operators, ineffective stun or recovering of consciousness before neck cutting and when both carotids are not severed during the first intervention	<ul style="list-style-type: none"> • Apply proper stunning and proper stun-to-stick interval • Train staff to monitor consciousness and use backup method before re-cutting • Train the staff to adequately sever the carotids 	None
Stimulation of wound (3.6.3.5)	Pain	Staff, equipment (failure in automatic cut)	Lack of skilled operators, physical contact with the open wound due to the restraint or during manipulation	<ul style="list-style-type: none"> • Adapt the equipment to avoid physical contact with the wound • Staff training to avoid manipulating the wound 	None

Hazard*	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Bleeding to death (3.6.3.6)	Pain, fear, distress	Staff, equipment	Lack of skilled operators, ineffective stun or recovery of consciousness during bleeding	<ul style="list-style-type: none"> • Apply proper stunning and proper stun-to-stick interval • Train staff to monitor consciousness and use backup method before re-cutting • Train the staff to adequately sever carotids 	None
Bird entering the scalding tank alive (3.6.3.7)	Consciousness, pain, fear, distress	Staff, equipment (failure in automatic cut)	Lack of skilled operators, short bleeding time, incomplete section of both arteries and jugular veins, lack of monitoring of death before entering the scalding tank.	<ul style="list-style-type: none"> • Staff training • Ensuring death before entering the scalding tank 	None

ABMs: signs of consciousness, wing flapping, withdrawal reaction, head shaking

ABM: animal-based measure; SOP: standard operating procedure.

*: The hazards apply to only a portion of birds: those ineffectively stunned or recovering consciousness following stunning.

Table 21: Outcome table on 'bleeding during slaughter without stunning': hazards (with the number of the section where the hazard's full description is provided), relevant welfare consequences, ABMs, origin of hazards, and preventive and corrective measures

Hazard*	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Manual restraint (3.6.2.1)	Pain, fear	Staff	Requirement of the method	None	None
Inversion (3.6.2.2)	Pain, fear	Equipment	Shackling or restraint in a cone	None	None
Shackling (3.6.2.3)	Pain, fear	Equipment	Shackling is part of the method	None	None
Drops, curves and inclination of shackle line (3.6.2.5)	Pain, fear	Equipment, facility	Poor design, layout and construction of shackle line	Redesign shackle line to avoid these hazards	None

Hazard*	Welfare consequence/s occurring to the birds due to the hazard	Hazard origin/s	Hazard origin specification	Preventive measure/s for hazard (implementation of SOP)	Corrective measure/s for the hazard
Inappropriate shackling (3.6.2.4)	Pain, fear	Staff, equipment	Lack of skilled operators; operator fatigue; rough handling during catching, crating and uncrating; fast line speed; size and design of the shackle inappropriate for the bird size; force applied during shackling	<ul style="list-style-type: none"> • Staff training • Staff rotation • Appropriate number of people shackling to match the line speed • Shackle carefully • Size and design of shackle appropriate for bird size • Stun the birds before shackling • Kill injured birds before shackling 	Shackle correctly
Neck cutting (3.6.3.3)	Pain	Staff	Neck cutting of conscious birds is a part of the method	None	None
Incomplete sectioning of carotids (3.6.3.2)	Pain, fear	Staff	Lack of skilled operators, blunt knife	<ul style="list-style-type: none"> • Training of staff • Use sharp knife • Ensure both carotid arteries are cut 	Completely cut both arteries
Repeated cuts (3.6.3.4)	Pain, distress	Staff	Lack of skilled operators	<ul style="list-style-type: none"> • Training of staff to avoid repeated cut • Apply stunning 	None
Stimulation of wound (3.6.3.5)	Pain	Staff	Lack of skilled operators, physical contact with the open wound due to the restraint or during manipulation	<ul style="list-style-type: none"> • Adapt the equipment to avoid the physical contact with the wound • Staff training to avoid manipulating the wound 	None
Bleeding to death (3.6.3.6)	Pain, fear, distress	Staff	Method requires inducing death through bleeding of conscious animals	None	None
Birds entering the scalding tank alive (3.6.3.7)	Consciousness, pain, fear, distress	Staff	Lack of skilled operators, short bleeding time, incomplete section of both carotids, lack of monitoring of death before birds enter the scalding tank.	<ul style="list-style-type: none"> • Staff training • Ensuring birds are dead before they enter the scalding tank 	None

ABMs: signs of consciousness, injuries, vocalisations, wing flapping, attempt to regain posture, withdrawal reactions, head shaking

ABM: animal-based measure; SOP: standard operating procedure.

*: These hazards apply to all birds because they are conscious.

4. Conclusions

4.1. General conclusions

This scientific opinion focuses on the identification of hazards leading to negative poultry welfare consequences at slaughter. The hazards, their origins, preventive and corrective measures, welfare consequences and related ABMs have been identified based on literature search and expert opinion, taking common slaughter practices into account. The conclusions are reported in the outcome tables.

The outcome tables concisely summarise the main results of this opinion.

Uncertainty in this opinion mainly relates to the possibilities of (i) incomplete listing of hazards, i.e. some welfare-related hazards may be missing in the identification process by being considered non-existent or not relevant (false negatives); and (ii) hazards not relevant to the welfare of poultry at slaughter being included in the outcome tables (false positives).

The uncertainty analysis on the set of hazards for each process provided in this opinion revealed that the experts were 90–95% certain they had identified the main and most common welfare hazards considered in this assessment according to the three criteria described in the Interpretation of ToRs. However, when considering the situation worldwide, there is a 95–99% certainty that at least one welfare hazard is missing. At the same time, the experts were 95–99% certain that all listed hazards exist during slaughter of poultry except in the case of LAPS (see Conclusion number 10 of Section 4.3).

Similarly, uncertainty exists related to the possibility of incomplete or misclassified listing of hazard origins, preventive and corrective measures, welfare consequences and ABMs, but owing to the limited time available to develop this scientific opinion, there is no uncertainty analysis of this.

- 1) In total, 35 welfare-related hazards were identified, from arrival of the birds at the slaughter plant until they are dead. Some of these hazards are common to different phases.
- 2) Animal welfare consequences can be the result of single or several hazards. The combination of hazards would lead to a cumulative effect on the welfare consequences (e.g. pain due to injury caused by rough handling during catching will lead to more severe pain during shackling).
- 3) Exposure to some hazards might persist along processes and phases until the birds are unconscious (e.g. food and water deprivation). Other hazards might be present only during one phase, but the welfare consequence might persist during the following phases (e.g. pain due to rough handling).
- 4) In total, 10 negative welfare consequences that can be experienced by poultry during slaughter have been identified. They are: consciousness, heat stress, cold stress, prolonged thirst, prolonged hunger, restriction of movements, pain, fear, distress and respiratory distress.
- 5) The birds will experience the negative welfare consequences of the hazards they are submitted to only when conscious. 'Consciousness' is considered a welfare consequence of poor stunning or of slaughter without stunning, and a pre-requisite for other welfare consequences the birds could experience, such as pain and fear.
- 6) All animals will experience the welfare consequences of the hazards happening during the pre-stunning phase, restraint (when applied to conscious animals) and slaughter without stunning. Only a proportion of animals will be subjected to the welfare consequences of hazards they are exposed after stunning: these are the animals for which stunning was ineffective and/or that recovered consciousness before death.
- 7) Lack of staff training is a major contributor to many of the hazards (28 out of 35 hazards).
- 8) Good design of the slaughterhouse is considered a pre-requisite for safeguarding the welfare of the animals. Even in a well-designed and equipped slaughter plant, staff training is critical in ensuring the protection of animals.
- 9) Even if welfare consequences cannot be assessed at the slaughterhouse, it does not imply they do not exist.
- 10) Under certain circumstances, not all ABMs can be used to assess welfare consequences because of low feasibility (e.g. at arrival/during lairage due to inaccessibility of the animals in containers).
- 11) For most of the hazards, preventive measures can be put in place, whereas relevant corrective measures are not always available.

- 12) If measures correcting the hazard are not applied, a welfare consequence will persist until the animal is unconscious or dead.
- 13) In Phases 2 and 3, stun/re-stun with a back-up method or emergency killing are the methods to mitigate the welfare consequences when measures to correct the hazards are not available.
- 14) Concerning methods, procedures or practices that cannot be considered acceptable in the context of this opinion, the Panel agrees with the principles of the OIE Terrestrial code regarding unacceptable methods. On this basis, examples of such methods are: electro-immobilisation for neck-cutting or preventing wing flapping during bleeding, and brain piercing through the skull without prior stunning.

4.2. Conclusions specific to Phase 1 – pre-stunning

Phase 1 (pre-stunning) includes the following processes: arrival, unloading, lairage, and handling and removing birds from crates or containers; the information can be retrieved in Tables 9–12.

- 1) Eleven hazards were identified in this phase, ten of which have staff as origin (ToR-1).
- 2) Some welfare consequences identified in Phase 1 might be the result of exposure to hazards occurring on the farm and/or during transport (e.g. prolonged hunger) (ToR-2).
- 3) In the context of the slaughterhouse, some welfare consequences have no ABMs (e.g. prolonged thirst), and others have ABMs that are very difficult to assess while birds are inside the containers (e.g. fear). In these cases, emphasis should be given to the preventive measures (ToR-2).
- 4) Preventive measures can be put in place for all the hazards identified in this phase, but there are no corrective actions for five out of the 11 hazards (ToR-3).
- 5) All preventive and corrective measures relate to two domains: 1) the maintenance of the physiology of the birds (e.g. provide good ventilation to avoid heat stress); 2) the prevention/correction of pain and fear (e.g. gentle handling of the birds in containers and individually) (ToR-3).

4.3. Conclusions specific to Phase 2 – stunning

Phase 2 (stunning) includes the following methods (with relevant restraint, if any): head-only and waterbath electrical stunning, captive bolt stunning, percussive blow, cervical dislocation, CAS (gas stunning and LAPS); the information can be retrieved in Tables 13–19.

- 1) Seventeen hazards were identified in this phase. The number of hazards an animal can experience depends on the stunning method used. Most of the hazards lead to pain and fear, some of them also to consciousness. Twelve of them have staff as origin. Depending on the method, a hazard can have different origins (e.g. 'too short exposure time' for CAS, where the origins identified were staff and equipment, whereas, for electrical methods, only staff were identified as origin) (ToR-1).
- 2) All the stunning methods described in this opinion have hazards: some methods present hazards related to the induction of unconsciousness (CAS), others to the restraint of birds (i.e. electrical and mechanical methods) (ToR-1).
- 3) Some hazards are inherent in the stunning method and cannot be avoided (e.g. shackling for waterbath electrical stunning), other hazards originate from suboptimal application of the method, mainly due to unskilled staff (e.g. rough handling, use of wrong parameters in the case of electrical methods) (ToR-1).
- 4) In Phase 2, the same welfare consequences may be assessed by diverse ABMs depending on the stunning method (e.g. wing flapping can be used to measure fear following gas stunning, and attempt to regain posture in waterbath electrical stunning) (ToR-2).
- 5) Hanging upside down is a physiologically abnormal posture for poultry; inversion, and shackling are practices that cause pain and fear in conscious birds (ToR-2).
- 6) In electrical waterbath stunning, not all birds processed at the same time receive the same current. Therefore, due to the electrical settings usually used, some birds don't receive sufficient current to become unconscious (ToR-2).
- 7) Cervical dislocation does not always lead to immediate onset of unconsciousness (ToR-2).

- 8) For some hazards (4 out of 17) there are no preventive measures other than 'change the method' because the hazard is part of the method (e.g. in the case of shackling of conscious animal in electrical stunning) (ToR-3).
- 9) For most of the hazards (11 out of 17) there are no corrective measures available (e.g. for the hazard 'pre-stun shocks' in electrical waterbath stunning and for the hazard 'too fast decompression' in the case of LAPS) (ToR-3).
- 10) For the hazard 'expansion of gases in the body cavity' related to LAPS, the lack of field experience and of scientific data has reduced the global certainty level of this hazard being a false-positive to 33–66%.

4.4. Conclusions specific to Phase-3 – bleeding

Phase 3 (bleeding) includes bleeding following stunning and during slaughter without stunning; the latter also includes the restraint; relevant information can be retrieved in Tables 20 and 21.

- 1) Twelve hazards have been identified in this phase; of these 12, 5 relate to restraint occurring during slaughter without stunning. All the remaining seven have staff as origin, and in the case of bleeding following stunning, six also have equipment as origin (ToR-1).
- 2) Bleeding during slaughter without stunning will expose 100% of animals to hazards that apply to the bleeding phase (except the hazards leading to recovery of consciousness). In the case of bleeding following stunning, only a proportion of the birds will be exposed to hazards occurring during bleeding: those that were incorrectly stunned and still conscious and those that recover consciousness prior to death (ToR-1).
- 3) Birds subjected to ineffective stunning or that recover consciousness after stunning are experiencing the welfare consequences related to the hazards they were exposed to in Phase 3. Pain will be the main welfare consequence experienced by these animals (ToR-2).
- 4) In bleeding following stunning, preventive measures can be put in place for all hazards, whereas corrective measures are available for only one hazard out of seven ('incomplete sectioning of carotids') (ToR-3).
- 5) In the case of bleeding during slaughter without stunning, for 5 out of 11 hazards there are no preventive measures other than 'change the method' because the hazard is part of the method (e.g. in the case of 'neck cutting') and corrective measures are available only for two of the eleven identified hazards ('inappropriate shackling' and 'incomplete sectioning of carotids'). The use of this method will therefore lead to unavoidable pain, fear and distress (ToR-3).

5. Recommendations

- 1) The welfare status of birds should be assessed and monitored at each phase of slaughter by assessing the ABMs provided in this opinion and identifying the existing hazards. If the hazard is present and use of ABMs is not feasible, it should be assumed that the related welfare consequences are also experienced by the birds.
- 2) Priority should be given to the implementation of preventive measures. When the bird is already exposed to an identified hazard, appropriate corrective measures should be applied (see outcome tables).
- 3) When no measures to correct the hazard exist, measures to mitigate the welfare consequences should be put in place.
- 4) All processes of the slaughtering should be carried out by trained and skilled personnel, and also involve proper maintenance and use of the equipment and facilities.
- 5) Training of staff in the different processes of slaughter should be implemented, with clear identification of roles and responsibilities.
- 6) The responsible person of the slaughterhouse should put adequate actions in place to prevent the occurrence of hazards and guarantee that birds do not suffer from avoidable pain, fear and other (negative) welfare consequences. Such measures should include (i) inspection and maintenance of containers, (ii) staff training and rotation, (iii) appropriate setting and use of equipment (see outcome tables).
- 7) Birds delivered in containers should be removed one at a time using both hands.
- 8) A back-up stunning method should be ready at all times to reduce the welfare consequences experienced animals if the first stunning method fails.

- 9) Birds should be prevented from recovering consciousness after stunning as it might expose them to the hazards that are associated with bleeding and that can cause severe welfare consequences, such as pain, fear and distress.
- 10) All stunning methods should allow monitoring for unconsciousness before birds enter the bleeding phase.
- 11) During the bleeding phase, unconsciousness should be monitored until birds are dead.
- 12) For electrical waterbath stunning of poultry, the parameters that should be used are reported in Table 2 of this opinion, except for broilers and turkeys for which the frequency should not exceed 600 Hz.
- 13) Cervical dislocation should not be used for routine stunning of birds; it should only be applied as back-up method when other suitable back-up methods are not available.
- 14) Manual cervical dislocation should not be applied to ducks and geese, and to any bird heavier than 3 kg.
- 15) Cervical dislocation by crushing should not be used under any circumstances.
- 16) Decapitation should only be applied to kill unconscious birds.
- 17) To prevent birds experiencing severe welfare consequences such as pain and fear:
 - animals should not be shackled while conscious;
 - animals should not be bled while conscious;
 - death must be monitored and confirmed in birds before they enter the scalding tank.
- 18) To be able to prioritise actions and improve procedures during the slaughter of poultry, hazards should be ranked in terms of severity, magnitude and frequency of the welfare consequences experienced by the birds.

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Glossary

Animal-based measure	a response of an animal or an effect on an animal. It can be taken directly from the animal or indirectly and includes the use of animal records (EFSA AHAW Panel, 2012a).
Corrective measure	measure that can put in place to correct an existing hazard.
Depopulation	the process of killing animals for public health, animal health, animal welfare or environmental reasons under the supervision of the competent authority (Council Regulation (EC) No. 1099/2009).
Emergency killing	the killing of animals that are injured or have a disease associated with severe pain or suffering and where there is no other practical possibility to alleviate this pain or suffering.
Hazard	any aspect of the environment of the animal in relation to housing and management, animal genetic selection or transport and slaughter that may have the potential to cause poor welfare (EFSA AHAW Panel, 2012a).
Inversion	holding birds in an upside down position.
Killing	any intentionally induced process that causes the death of an animal (Council Regulation (EC) No 1099/2009).
Lairaging	keeping animals in stalls, pens, covered areas or fields associated with or part of slaughterhouse operations (Council Regulation (EC) No 1099/2009).
Mitigation measure	measure that can put in place to reduce the welfare consequences/s.
Pithing	the laceration of the central nervous tissue and spinal cord by means of an elongated rod-shaped instrument introduced into the cranial cavity (Council Regulation (EC) No 1099/2009).
Poultry	all domesticated birds, including backyard poultry, used for the production of meat or eggs for consumption, for the production of other commercial products, for restocking supplies of game, or for breeding these categories of birds, as well as fighting cocks used for any purpose. Birds that are kept in captivity for any reason other than those reasons referred to in the preceding paragraph, including those that are kept for shows, races, exhibitions, competitions or for breeding or selling these categories of birds as well as pet birds, are not considered to be poultry (OIE, 2019 Glossary).
Preventive measure	measure that can put in place to prevent the occurrence of a hazard.
Related operations	operations such as handling, lairaging, restraining, stunning and bleeding of animals taking place in the context and at the location where they are to be killed (Council Regulation (EC) No 1099/2009).
Restraint	the application to an animal of any procedure designed to restrict its movements, sparing any avoidable pain, fear or agitation to facilitate effective stunning and killing (Council Regulation (EC) No 1099/2009).
Shackling	hanging birds upside down by inserting both legs into metal shackles.
Slaughtering	the killing of animals intended for human consumption (Council Regulation (EC) No 1099/2009).
Standard Operating Procedures	a set of written instructions aimed at achieving uniformity of the performance of a specific function or standard (Council Regulation (EC) No 1099/2009).
Stunning	any intentionally induced process which causes loss of consciousness and sensibility without pain, including any process resulting in instantaneous death (Council Regulation (EC) No 1099/2009).
Welfare consequence	the change in welfare that results from the effect of one or more factors (EFSA AHAW Panel, 2012a).

Abbreviations

ABM	animal-based measure
AC	alternating current
AEP	auditory evoked potential
AHAW	Animal Health and Welfare
AVMA	American Veterinary Medical Association
CAS	controlled atmosphere stunning
CBS	captive bolt stunning (penetrating or non-penetrating)
CD	cervical dislocation
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DoA	dead on arrival
EEG	Electroencephalogram
FBO	food business operator
GAS	gas atmosphere stunning
HO	HEAD-only electrical stunning
HSA	Human Slaughter Association
LAPS	low atmospheric pressure stunning
LS	literature search
MCD	manual neck or cervical dislocation
MS	Member State
NCP	National Contact Point
OIE	World Organisation for Animal Health
RH	relative humidity
RMS	root mean square
SOP	standard operating procedure
ToR	Term of Reference
WB	waterbath electrical stunning
WG	Working Group

Appendix A – Literature search (LS)

As described in Section 2.2.1, a LS was carried out to identify peer-reviewed scientific evidence on the topic of 'slaughter of poultry' that could provide information on the elements requested by the ToRs, i.e.: description of the processes, identification of hazards, origins, preventive and corrective measures, welfare consequences and ABMs).

To obtain this, firstly a broad LS under the framework of 'welfare of poultry at slaughter and killing' was carried out, and the results were successively screened and refined as described below.

Sources of information included in the search

Bibliographic database: Web of Science.

Search string used in the bibliographic database

The search string was designed to retrieve relevant documents to 'animal welfare' during 'slaughter and killing' of 'poultry'. Restrictions on the different species of poultry were applied by including the genus name of different species of birds that are used for human consumption to obtain studies concerning domesticated birds used for meat production. Restrictions applied in the search string were also related to the processes characterising 'slaughter and killing' (from arrival to bleeding) of animals in containers, and the date of publication (considering only those records published after EFSA, 2004). No language or document type restrictions were applied in the search string.

Web of science (all databases)

Date of the search: 19 December 2018

Set	Query	Results
#1	Ts = Welfare OR 'animal welfare' AND slaughter* OR kill* OR stun* AND bird* OR poultry* OR chicken* OR <i>gallus</i> OR turkey* OR <i>meleagris</i> OR quail* OR <i>callipepla</i> OR duck* OR <i>anas</i> OR geese OR goose OR anserini OR <i>pheasant</i> * OR <i>phasianus</i> OR partridge* OR <i>perdix</i> OR pigeon* OR <i>columbidae</i> OR pullet* OR fowl* OR <i>galloanserae</i> OR guinea fowl OR <i>numididae</i> OR hen* AND Arriv* OR *load* OR lairage* OR handl* OR mov* OR restrain* OR cut* OR bleed* OR cage* OR crate* OR *conscious* OR pain* OR behav* OR stress* Timespan = 2004–2018 Search language = Auto	412

Refinement of literature search results

The search yielded a total of 412 records that were exported to an EndNote library together with the relevant metadata (e.g. title, authors, abstract). Titles and abstracts were firstly screened to remove irrelevant publications (e.g. related to species, productive systems, processes and research purposes that were out of the scope of this opinion) and duplicates, and successively to identify their relevance to two topics: 'slaughter of poultry' and 'on-farm killing of poultry'. Full text publications were screened if title and abstract did not allow assessing the relevance of a paper. The screening was performed by one reviewer, with support by a second reviewer in cases of doubt; publications that were not considered relevant nor providing any additional value to address the question were also removed. The screening led to 69 relevant records, 50 pertaining to 'slaughter of poultry' and 21 to 'on-farm killing of poultry' (two papers were relevant for both topics).

The resulting list of 50 publications relevant to 'slaughter of poultry' is reported in Table A.1.

Table A.1: List of publications relevant to 'slaughter of poultry' resulting from the LS

ID	Reference
1	Abeyesinghe et al. (2007)
2	Ali et al. (2007)
3	Ali et al. (2008)
4	Barnett et al. (2007)
5	Bedanova et al. (2007)
6	Berg and Raj (2015)

ID	Reference
7	Beyssen et al. (2004)
8	Caffrey et al. (2017)
9	Chauvin et al. (2011)
10	Coenen et al. (2009)
11	Cranley (2016)
12	Gerritzen et al. (2007)
13	Gerritzen et al. (2013)
14	Girasole et al. (2015)
15	Girasole et al. (2016)
16	Grilli et al. (2015)
17	Hindle et al. (2010)
18	Jacobs et al. (2017)
19	Jacobs et al. (2016)
20	Jiang et al. (2015)
21	Kittelsen et al. (2015)
22	Lambooij et al. (2014)
23	Lines et al. (2011)
24	Mackie and McKeegan (2016)
25	Martin et al. (2016a)
26	Martin et al. (2016b)
27	Martin et al. (2016c)
28	Martin et al. (2018)
29	McKeegan et al. (2006)
30	McKeegan et al. (2007a)
31	McKeegan et al. (2007b)
32	Medina-Vara et al. (2016)
33	Nicolau et al. (2015)
34	Nijdam et al. (2004)
35	Petracci et al. (2006)
36	Raj and O'Callaghan (2004a)
37	Raj and O'Callaghan (2004b)
38	Raj et al. (2006a)
39	Raj et al. (2006b)
40	Raj et al. (2006c)
41	Raj (2006)
42	Rodrigues et al. (2017)
43	Shields and Raj (2010a,b)
44	Vieira et al. (2010)
45	Vieira et al. (2011a)
46	Vieira et al. (2011b)
47	Villarroel et al. (2018)
48	Vizzier-Thaxton et al. (2010)
49	Warriss et al. (2007)
50	Webster and Fletcher (2004)